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Applying User-Centered Design in the Development of a Software Application For the Treatment of a Mental Health Disorder

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Applying User-Centered Design in the Development of a Software Application For the Treatment of a Mental Health Disorder

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CONTENTS

List of Tables

List of Figures

INTRODUCTION

Fear towards a specific object or situation can cause increased anxiety in individuals and can interrupt daily life. Whether the fear is real or imagined the physical and mental state of a person's health contributes to maintaining a stable, happy lifestyle (Weiderhold et al., 1991). Individuals suffering from phobias and other mental health disorders are all too familiar with the effects that they can have on overall happiness and ease of life. What most would perceive as common tasks, like taking a flight, can be impossible obstacles for others (Weiderhold et al., 1991).

Phobias are the most common form of anxiety disorder, but they are treatable. As part of the computer science field, virtual reality offers an alternative to standard therapy for mental health disorders that immerses patients into interactive, three-dimensional worlds. These virtual worlds expose humans to objects and/or situations that may be unlikely or impossible in the real world.

The research that follows will provide a process for applying a user-centered design methodology to the development of a virtual environment software application for the treatment of a mental health disorder, specifically post traumatic stress disorder (PTSD). The goal is to create a screen-based virtual environment product that focuses on the end user rather than the technological aspects of the system. Moreover, past and present treatments in the mental health and healthcare fields and their effectiveness will be analyzed through an extensive literature review.

Definition

Virtual Reality Exposure Therapy (VRET) is a technique used in the treatment of various mental health disorders, such as anxiety and PTSD that subjects patients to anxiety-inducing stimuli, while allowing these anxieties to heighten over time. Once a patient's comfort level increases, the anxiety decreases. This occurs naturally as they spend more and more time in each situation (Strickland, Hodges, North & Weghorst, 1997).

Barbara O. Rothbaum, Ph.D., from Emory Clinic in Atlanta, describes virtual reality as the use of "real-time computer graphics, body tracking devices, virtual displays and other sensory input devices to immerse participants in a computer-generated virtual environment" (Kaplan, 2000).

History

In traditional exposure therapy practices, stimuli were created by presenting patients with real-world situations. The onset of virtual reality therapy has brought about safer, less embarrassing, more economical solutions to the previous task. The cost to produce the actual physical experience is eliminated by creating an imaginary danger. Additionally, patients can choose to increase or reduce the level of stimulation throughout the experience based on his/her comfort level (Strickland, Hodges, North & Weghorst,1997).

The key to a successful virtual environment (VE) is to employ high-quality sensory engagement. This level of quality is achieved through immersion. Some applications produce heightened emotions where the user believes the situation to be real. Increased heart rate and physical attributes, like tightened and clenched muscles, are forms of measurement that support these findings (Whitton 2003, p 40-46).

Premature enthusiasm for virtual reality technology has been generated from the media. But overall, virtual reality experiences are disappointing. Do not confuse this statement with the effectiveness of virtual reality. Studies have shown virtual reality therapy to be as, if not more, effective than traditional standard therapy. Although headset imagery remains poor and environments resemble cartoons and lack realism, it has been shown that this does not affect the level of immersion or success rates offered by traditional virtual reality software. Although virtual reality technology is still lacking in its visual requirements, the new paradigm offered by the technology in which users are no longer simple observers but are active participants is promising. There are still many things that we cannot do well with virtual technology but the general consensus is positive as to what the future holds (Strickland, 1996). Human factors are undeniably missing from many virtual reality systems. Here is where user-interface engineers can help improve the technology with their expertise in intuitive interface design and the total user experience.

As previously stated, studies have shown virtual reality therapy to be effective in the treatment of various phobias. While immersing patients into stress-inducing environments virtually is promising, the approach is not yet widely accepted. In order to gain greater acceptance, the usability of virtual reality must be improved upon. Further investigation into the user experience is necessary (Schuemie 2002, p 834-835).

The secret is the overall quality of the user experience (Usernomics, 2002). The focus will be on the improvement of the user experience through the user-interface design, the virtual environment in this case. Unlike technology specialists, the role of usability specialists will be used to focus on the user interface (Usernomics, 2002). Current interface strategies for virtual environments are often times unnatural and not intuitive. It has been argued that the user interface is the least satisfactory component in today's virtual reality systems (Whitton 2003, p 40-46).

To arrive at the realization of an optimized user interface, close collaboration between computer technology and people technology is required. A tool that is usable by every type person is the goal. This goal can be narrowed by the specification of a target audience (Foley 1994, p 34-43). The effective communication between computer and people is the main goal. The creation of a virtual environment that emulates the real world through the use of lifelike video game caliber graphics is the intended strategy to increase the realism of the product interface. User-centered design (UCD) techniques will be applied to gain insight into the end-user's experience, in this case the sufferer of PTSD. Based on UCD methodologies and techniques, suggestions and recommendations will be made toward the improvement of the user interface. Areas of concentration will be weak or unnatural areas of the interface design.

The goal is to generate all-inclusive sensory involvement to produce an accessible, usable product where individuals are empowered, not overwhelmed. The ideal product will be as seamless to the user as that of an automobile or telephone. This entirely ubiquitous goal may not be realistic to date, but this paper will move research in that direction. In a perfect world, obtrusive headgear will disappear and interaction will occur in a more seamless way.

Statement of Problem

At present, Virtual Reality Exposure Therapy (VRET) research has developed some interesting findings. As VRET slowly gains therapists' acceptance as a means for curing various phobias, several studies have already reported VRET to be an effective treatment for mental health disorders, and a tool used in varying degrees within the medical field (van der Mast, Emmelkamp and Jansen 2004). But, is current virtual reality software capable of helping people overcome anxieties associated with certain fears? If so, what findings are there to support this?

The acceptance of the virtual reality technology was not well received by the mainstream computing as first anticipated. Much of today's virtual reality use is contained in medical and educational facilities. One reason for this lack of acceptance is the apprehension of the unknown (Lindenman, Sibert & Hahn 1999, p 64-71). Currently, there is not enough information regarding the user interface or virtual environment. One resource unveils pragmatic results gathered from actual experiments developed to provide insight into the successful user interface. The Immersive Virtual Environment (IVE) is an interactive world where users are cut off from external real world elements unrelated to the experience (Lindenman, Sibert & Hahn 1999, p 64-71). The use of 2D windows in 3D worlds has been used in recent interface design for IVEs. The simplest design elements are born from human intuition, similar to the design of existing desktop themes. In order to provide optimum interface usability the details that make up these interfaces must be explored, as was done in the development of the desktop (Lindenman, Sibert & Hahn 1999, p 64-71).

The idea of the VE alone is compelling. In contrast, the creation of a VE that is actually compelling requires much time and knowledge. An ideal VE allows users to travel places, do things, and experience things they would not otherwise be able to in the real world because of a fear or lack of opportunity. The average human experience with virtual reality technology is in the entertainment category. These particular devices are designed to be fun and adventure-enhancing. The initial "wow" factor delivered by the technology makes the overall experience exciting. The reality of virtual reality is not what is seen in movies such as *The Matrix* and *Star Trek.* The ability to create limitless virtual reality spaces in which one can pick up virtual objects or sit on virtual furniture is not yet available. Despite the current limitations of virtual reality systems, successful, intriguing VE applications still exist (Foley 1994, p 34-43).

Not all are convinced of this level of immersion. Some remain highly sensitive to their surroundings and cannot fully immerse into the experience. The job of the interface designer is to create a compelling, intuitive environment where users are fully motivated toward the experience and leave the laboratory behind. All in all, the most successful VE, in addition to high-quality immersion, is determined by the mental state induced by that environment. The user's mental state is evaluated by his/her reactions, whether or not they correspond to those of a real-life situation (Foley 1994, p 34-43).

Hypothesis

Findings that support or negate the following statements will be revealed throughout this paper.

1. The application of user-centered design techniques can increase the usability of current virtual environment therapy software.
2. Current technology is good enough to help people overcome anxieties related to certain mental health disorders.
3. Human factors can improve current virtual reality technology.

A literature review will provide insight into the above uncertainties. The step-by-step process used to apply a user-centered design methodology to a virtual environment software application will be revealed through a case study. The explanations given throughout this paper will help readers come to their own conclusions.

Scenario

The war in Iraq is far from over, fighting continues rapidly approaching its seventh year. Moreover, the U.S. Military is faced with what appears to be an imminent mental-health crisis in the armed forces. "One of every six Army soldiers returning from the war zone experiences major depression, anxiety or posttraumatic stress disorder" (Cha, 2005). And the percentage is even higher if those reporting milder symptoms are included.

Returning service men and women diagnosed with combat-related PTSD have been traumatized in some way by their war experience in Iraq. A traumatic event is defined by being outside the realm of normal human experience, such as military combat or a violent personal attack (Rizzo et al., 2004). Their symptoms, in accordance with the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV), are generally identified by:

- Cognitively re-experiencing the event (i.e. flashbacks, nightmares)
- Persistent avoidance of things that remind the person of the trauma
- Numbing of general responsiveness and hyper arousal (Ursano, 2005)

Furthermore, symptoms vary from veteran to veteran as does the healing process. PTSD is not prejudiced. It can happen to anyone who has been subject to enough stress. The severity of symptoms is related to the intensity and duration of the stress rather than a predisposed susceptibility towards mental illness. The war itself can be the traumatic event for combat veterans, or it can be as tragic as witnessing a death. Many can manage their trauma without undesirable effects, whereas combat veterans with PTSD relive their trauma over and over again. A person, place or thing that is reminiscent of the original experience often triggers this reoccurrence. Examples of common triggers are smells, weather, sounds or people. More specifically, sounds of helicopters, humid weather, sand and certain types of people can activate reoccurrences of traumatic events. An example of a response to a trigger is a veteran who jumps into a ditch when he hears a car backfire. The sound of a car backfiring may be reminiscent of a gun firing and his reaction to take cover. Avoidance is a common defense mechanism used by war veterans to minimize these reminders of unpleasant war memories.

The effects of combat-related PTSD can be far reaching, including a variety of side effects ranging from health problems, depression and substance abuse. An individual suffering from PTSD is not the only victim. Family and friends are also affected by symptoms that include low tolerance, isolation and helplessness. Intimate relationships can be sacrificed while one is experiencing the severe after-effects of war. War veterans and their families should not feel ashamed of this debilitating condition. There are treatments available to help people better cope with the effects of PTSD (Brossart, 2003).

All-in-all, incredible training resources are currently available to combat troops entering war, but an outstanding ethical responsibility is often ignored, how to deal with the after-effects of war on our service men and women. More and more veterans have reported symptoms of PTSD upon returning home from Iraq. These numbers tell the true story. There is not enough focus on dealing with the aftermath of a war (Rizzo et al., 2004).

LITERATURE REVIEW

Virtual reality technology has been around longer than most people think. It has been said that all of the basic elements of the technology existed by 1980. Pioneers like Ivan Sutherland were first on the scene in the late 1960s with his invention The Ultimate Display, a primitive head-mounted display. But it was flight simulation backed by the military that was most influential early on (http://archive.ncsa.uiuc.edu). Nonetheless, virtual reality did not become well known until the 1990s when it gained popularity for its entertainment value. The sensory-rich environments that are created with virtual reality allow users to be "somewhere else." Most people are familiar with the science-fiction movie, *The Matrix* where the characters sit in cushy chairs connected to a virtual world. Within this virtual world, they are engaged in heavy physical activity like fighting in eloquently choreographed martial arts scenes, evading bullets and racing down streets on high-tech motorbikes, while in the real world their bodies are seemingly at rest. All of this is made possible by complex software applications used to create virtual environments (Hoffman, 2004).

With its introduction into mainstream movies and television, virtual reality technology has been loosely accepted by the general public as a futuristic form of computing for their entertainment. On the flip side, researchers have found a practical use for it. Brenda Wiederhold, Ph.D., MBA, Executive Director of the Virtual Reality Medical Center (VRMC) in San Diego, California and National Institute of Drug Abuse (NIDA) grantee, explains that applications for virtual reality are being explored in four primary areas including anxiety disorders, eating disorders, distraction techniques, and medical training and assessment (Kaplan, 2000).

Mental Health Disorders

Fear of Flying

The use of virtual reality in therapy has been suggested as a means to treat various phobias (Hoffman, 2004). Reports following the 8th Annual Medicine Meets Virtual Reality Conference held in Newport Beach, California found that patients afraid of flying are responding favorably to virtual reality exposure therapy (VRET) (Kaplan, 2000).

When a patient enters a virtual world, they come face-to-face with their fears and are able to come to terms with these fears through constant exposure. This confrontation of fears takes place in a controlled setting, such as a laboratory. The use of virtual reality helps patients merge the gap between what is real and what is imagined through regular exposure to a feared stimulus. Constant exposure to a fear makes it easier for the patient to cope with in real life (Bender, 2004).

Virtual reality itself is not the answer. It is only a tool used in combination with conventional therapies to aid in the treatment of deeper psychological obstacles. At the VRMC, headed by B. Weiderhold, along with her husband Mark, MD, Ph.D., president and NIDA grantee, clinicians use cognitive-behavioral therapy (CBT) in conjunction with virtual reality to treat patients with numerous phobias. Many phobic's develop dysfunctional associations with regards to their fears and need psychological help to dissect them. Virtual reality can simulate a physical environment but cannot determine the reason a fear exists (Bender, 2004).

Prior to the use of virtual reality in the treatment of mental health disorders patients' choices were limited. They had two options: visualization (in vivo therapy) or exposure (in vitro therapy). Visualization or imagine therapy requires patients' to visualize themselves interfacing with their fear. For example, a patient with a fear of flying would mentally visualize the flight experience. They would have to imagine themselves driving to the airport, checking in, going through security, walking to the gate and sitting on the plane or taxiing down the runway. Dr. B. Weiderhold notes that most people's visualization skills are not that refined, making it difficult to increase the patients' anxiety levels strictly through the use of his/her own imagination. In other cases, patients visited actual airports and were seated on empty planes to help overcome their fears. This is an example of exposure — where a patient physically reveals himself to the object of fear. Due to increases in airport security after 9-11 this is no longer a viable option for this particular phobia (Bender, 2004).

Virtually Better, Inc., a company out of Decatur, Georgia, produces an airplane simulation, as well as several other virtual environments, developed to help people work through their phobias. With security increases for airports around the world, this is a modern solution to exposure therapy. It differs from traditional exposure therapy because it is simulated. The therapist no longer has to accompany the patient to the airport; the airport comes to the office (Smith, 2003). This proves to be a major benefit for virtual reality therapy. Therapy that takes place in an office setting is less embarrassing for patients and makes the access of emotions easier than in a public place, an obstacle in

traditional exposure therapy. Because of reluctance to public therapy in the past, low volumes of people suffering from phobias actually sought treatment. It is overwhelming, and in some cases dangerous, to expose one to what they have been avoiding (Bender, 2004).

Using the Virtually Better, Inc. airplane simulation the patient wears a headset that houses earphones and sits in a chair, much like that on a real airplane, atop a platform. The therapist is nearby monitoring the session on a desktop computer (Smith, 2003).

Figure 1: Virtually Better, Inc. airplane environment (from left to right: plane take-off, plane inside, back of seat in plane)

The entrance to the cabin of the aircraft is visualized by the patient. The audio the patient hears through the earphones include the roar of the engine and the flight announcements made at the beginning of an ordinary flight. The platform is used to recreate the motion that is felt during take-off and landing. Here the patient actually experiences a sense of presence and immersion. In traditional imagine therapy it is easy to avoid the feared imagery. In the simulated environment avoidance is not an option. The patient cannot deny that the platform is vibrating or the sounds are being heard (Smith, 2003).

Good news for virtual reality is that it is proving to be as, if not more, effective than standard exposure therapy. Samantha Smith, Ph.D., of Walter Reed Army Medical Center in Washington, D.C. worked with approximately 45 patients with a fear of flying. The patients were divided into three groups: one received standard exposure therapy (included regular trips to the airport, seating on airplanes and on real flights); the second used virtual reality; and the third did not receive treatment. Smith reported that after the completion of therapy, the first two groups showed lower levels of anxiety associated with flying than patients in the third group (Smith, 2003).

Post Traumatic Stress Disorder

Virtual reality therapy began as a treatment for patients with a fear of flight but has progressed into treatments for other disorders like Post Traumatic Stress Disorder (PTSD) and eating disorders.

Many of the men and women who serve our country overseas experience symptoms of PTSD. These patients are looking for ways to return to their civilian lives without difficulty while alleviating the trauma that they experienced during active duty. While their physical wounds will eventually fade, not all wounds are visible. The following is a list of characteristics commonly found in veterans experiencing PTSD.

1. Intrusive thoughts and flashbacks

2. Isolation

3. Emotional numbing

4. Depression

5. Anger

6. Substance abuse

7. Guilt/Suicidal thoughts and feelings

8. Anxiety and nervousness

9. Emotional constriction

10. Denial (Brossart and O'Dell, 2003).

There have been successful virtual reality applications developed for the treatment of Vietnam veterans. For example, a 14-session virtual reality protocol conducted by Dr. Rothbaum and her colleagues consisted of a Huey helicopter and a dense jungle simulation. It resulted in a 34 percent drop in symptoms for a 46-year old Vietnam combat veteran with PTSD. The same patient experienced an even larger percentage drop in his symptoms at the six-month mark. This reduction of symptoms was measured by the patient's reactions to the stressor after being exposed to the stimuli over and over again through the use of the virtual reality protocol mentioned above (Pueschel, 2004).

Many therapists find that their patients have difficulty engaging in standard therapy but show improvements with virtual reality therapy. Joann Difede, Ph.D., associate professor and director of the Program for Anxiety and Traumatic Stress Studies in the Department for Psychiatry at Weill Medical College within Cornell University, and NIDA grantee, said that imagine therapy has been the standard form of treatment since 1999 for PTSD and other depressive symptoms associated with traumatic events. Her findings are that some patients are unable or refuse to engage emotionally. Avoidance is an inherent characteristic of PTSD and can lead to patients fabricating lies to escape their emotions. Improvements to this problem are revealed through the use of virtual reality because it enhances and encourages emotional involvement (Pueschel, 2004).

Simulations for the World Trade Center (WTC) disaster have been developed to treat patients with depression as a result of the tragedy. A quarter of these patients could not engage emotionally through standard therapy alone, but with the addition of virtual reality therapy made large improvements. The software created by Dr. J. Difede and her colleagues provides a gradual hierarchy of exposure where the towers appear on a clear, sunny day; planes are flying overhead; a plane crashes into the tower; an explosion occurs; and sound is added. The therapist controls each patient's level of immergence into the tragedy through the use of a desktop computer. Once a patient is comfortable with this first engagement, later scenes include more graphic details like people jumping from the burning towers; towers collapsing to the ground; smoke, ash and debris flying through the air (Pueschel, 2004).

The following is a series of examples of WTC onlookers conquering emotional vulnerability through the use of virtual reality therapy.

(1) A high-functioning, single black female, 26-years old who worked across from the WTC was diagnosed with PTSD and co-morbid major depression in the aftermath of the attacks. When she emerged from the subway on the tragic morning she saw the first plane crash and then the second as she was trapped in a crowd trying to evacuate the scene. Her depression persisted and she was unable to engage in standard therapy. She reenacted the scene on her subway ride to work each day. J. Difede states however with six 60-minute sessions of virtual reality therapy the patient was able to recall events that she had not talked about with anyone since they occurred.

Through additional counseling, she was able to process her pain better. This particular woman experienced a reduction in symptoms of more than 50 percent. She also had fewer occurrences of the reenacted event and experienced less arousal triggering her depression.

(2) A second case was that of a fire chief who witnessed the crashes from across the Brooklyn Bridge and came into Manhattan to help. He also endured CBT and was unable to engage in standard exposure therapy. When he began with virtual reality therapy his emotional engagement increased. After only six sessions his PTSD symptoms were reduced by half. The software was able to pinpoint what triggered his symptoms. In this case, it was when the buildings collapsed.

(3) Lastly is the case of a fireman who was vacationing at the time of the attacks. If he were not on vacation he would have been there that day as well. In the meantime, ten of his men died that day helping. He was depressed and had survivor's guilt. He also could not engage in standard therapy. He was able to tap into his fear but not the grief and guilt associated with surviving the tragedy. With the use of virtual reality therapy he was able to talk about the friends he lost that day as well as the grief and anger he was feeling (Pueschel, 2004).

Eating Disorders

Dr. B. Weiderhold has stated that virtual reality therapy is also being used to treat eating disorders like anorexia, bulimia and obesity. It is used to help patients with distorted body perceptions. Denial is a major obstacle with patients of eating disorders. Previous eating disorder studies tried to get patients to view their bodies in a room of mirrors or in a photograph. Often times with this approach patients could not accept what they saw. Conversely, in a study of binge eating (bulimia), a group that was treated with virtual reality found that patients had more realistic body images, resulting in reduced overeating and binging, higher levels of body satisfaction and weight loss. Furthermore, the study showed that the patients treated with virtual reality therapy were less concerned with social weight standards as viewed on television and in magazines and they continued with therapy.

The advantages that virtual reality therapy elicited in the treatment of eating disorders as seen by Dr. B. Weiderhold are reduced patient anxiety in real world encounters and improved body image. The actual treatment uses images and tests to eliminate the patient's distorted thoughts and ideas about themselves. It teaches them the significance of thought and helps them discard inaccurate thoughts. It allows for healthy body exposure and requires patients to admit distortions long enough to move forward to the next stage of virtual reality treatment (Pueschel, 2004).

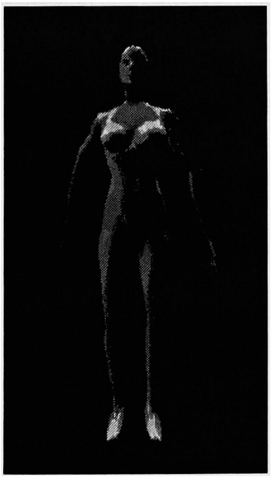


Figure 2: Average-size avatar

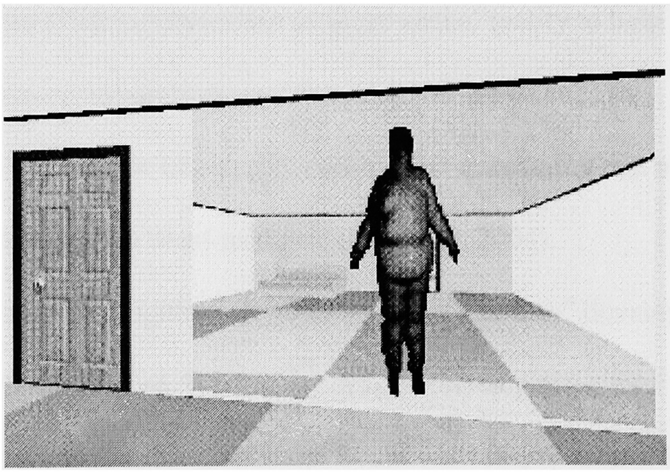


Figure 3: Virtual room in eating disorder software

The following is an actual case where virtual reality is being used as part of an eating disorder treatment program near Milan, Italy. Professor Giuseppe Riva treats patients suffering from anorexia and bulimia using an in-patient program which includes the use of virtual reality at the Instituto Auxologico Italiano. The program uses avatars, graphical images of the user that are built to scale from patients exact height, weight and physical measurements. Patients are asked to adjust an average-size avatar digitally to represent what they think they look like. Findings show that patients tend to add weight to the figure. When the patient-sized avatar is then placed next to the patient's true-size avatar the discrepancy is undeniable. This helps dismiss distorted body image. For example, when shown an actual photograph of themselves in an emaciated state they still deny the visual evidence that they are a mere skeleton of themselves. Nonetheless, when shown their true-size avatar on a computer screen, for some reason, the visuals are validated for the patient and they are no longer able to deny their physical weight. Patients are taught to rethink distorted perceptions they have of their bodies through the use of virtual reality (Edmonds, 2004).

Addiction

The treatment of addictions is one of the newest areas to adopt virtual reality to help patients. The virtual environments used in addiction treatment focus on the use of cues to artificially trigger cravings (Edmonds, 2004). Cues like smoke can suggest a steaming cup of coffee or even a smoky bar. These cues promote patient response (Pueschel, 2004).

For example, an existing virtual reality program referred to as "crack house," developed by Rothbaum, provides a simulation of a drug house. It takes the drug-addicted patient on a tour of an abandoned crack house. The patient views a dirty, unkempt house with empty rooms, little or no furniture and drug dealers and users that can be heard. The visuals and sounds that are mimicked throughout increase the patient's reactivity. Digital photos were taken of an existing crack house and then incorporated into the program to supplement the concept of using cues to enhance patient reactions. The cues used in the virtual reality treatment of addictions aid in determining the timing of cravings (Pueschel, 2004). This exposure to other users and things that make an addict crave a drug help doctors determine the triggers. Once the doctor has pinpointed the craving the addict can learn to fight these cravings. The environment also serves as a safe place for drug makers to test anti-craving medications (Edmonds, 2004).

Smoking is another addiction that is constantly being fought. Steve Baumann, at his Pittsburgh lab, guides smokers through two variations of a virtual environment: one with no references to smoking and another with packs of cigarettes, ashtrays, and advertisements. The latter is customized to replicate the brand of cigarettes smoked by a patient. Reports showed that on a scale of 1 to 100, patient cravings increased 15 points in the smoking world. Now that Baumann has found he can manipulate cravings through virtual reality the next question is: can patients be desensitized to the cravings, or helped to cope with them, once back in the real world (Edmonds, 2004)?

With the early success of virtual reality in the treatment of mental health disorders, additional avenues have opened for further research and advances. According to Walter Greenleaf, PhD, president of Greenleaf Medical in Palo Alto, California, virtual reality is rapidly being accepted into the medical community. The potential benefits of using virtual reality in the medical field are far reaching.

Medical Applications

Distraction Therapy

Research has also shown that virtual reality can help alleviate physical pain. The use of virtual reality simulators diverts a patient's attention away from their physical pain. By focusing their attention elsewhere the patient is able to deal with their pain better.

Hunter Hoffman, Ph.D., director of the HITLab VR Analgesia Research Center at the University of Washington in Seattle, references VR distraction as a form of treatment for the reduction of pain in burn patients where morphine has proven insufficient in controlling their pain (Pueschel, 2004). He has developed a new virtual reality world called "Snow World" for use in VR distraction (Rauterberg, 2004). It aids in the reduction of a burn victims physical pain by removing their focus from their physical pain and applying it to another object or task. In the Snow World environment patients are able to virtually shoot snowballs and view cooling images while having their burns treated (Pueschel, 2004). This plays on the idea that our level of pain is directly related to how much we pay attention to it.

Figure 4: Image of patient using Snow World while having his burn dressings changed. Background image shows the experience of flying a virtual fighter jet through an icy 3-D canyon, including shooting virtual snowballs at snowmen and igloos.

Hunter and colleagues took the Snow World application to another level by testing the degree of presence in a controlled laboratory study using undergraduate volunteers. Group 1 experienced an enhanced high-tech version designed to draw out strong illusions of presence in the virtual world. Group 2 experienced the low-tech version of Snow World. This version incorporated no head tracking, sound effects, animation, texture maps, or snowballs as were available in the high-tech version used by Group 1. The results found that the stronger the illusion of presence in the virtual world, the higher level of pain reduction.

Snow World is the second of two environments developed by Dr. H. Hoffman and colleague clinical psychologist David Patterson, both of Multigen-Paradigm. The first was called Spider World, developed using software from Division LTD. In this more-primitive application, patients touched a furry toy spider that was directly linked to a virtual spider. This distracted patients' attention from their pain to the spider. When they touched the spider in the cyber world they also felt the furry spider in the real world. Pain relief results were exciting. In a series of controlled studies at the Haborview Burn Center at the University of Washington, the team found that the use of virtual reality in burn treatment dramatically reduced patients' awareness of pain (O'Keefe, 2005).

Figure 5: Spider World (retrieved online http://www.hitl.washington.edu/projects/)

With the simple use of MultiGen-Paradigm, Inc. software products clinicians are able to develop new virtual reality worlds to help patients fight pain through the use of game-like activities (Rauterberg, 2004).

More advanced virtual reality treatment for burn victims involves a fiber optic helmet that is worn by patients who have to withstand treatment in scrub tanks, reserved for seriously burned patients. The treatment is so severe that oftentimes burn patients refuse the regular treatments required to restore full functionality to the burned parts of their bodies. This new advanced treatment must withstand actual water from the scrub tanks, a new obstacle for virtual reality. This is where the use of fiber optics comes into play, allowing images to be sent directly to the HMDs without the use of wires (Rauterberg, 2004). Magnet-friendly virtual reality software, yet another advancement for the treatment of burn victims, has been developed that allows patients' to enter Snow World while having a brain scan done (Pueschel, 2004).

Researchers have also found that virtual reality can aid in alleviating pain for children with serious injury or illness. Since the 1980s, Dr. Lynda Dahlquist of the University of Maryland has been researching the management of pediatric pain. In the past, electronic handheld games were the form of intervention for pediatric pain. Children played the game with one hand while receiving injections in the opposite arm. Dr. Dahlquist stated that children undergoing chemotherapy for cancer treatment have had significant success with these interventions. Nonetheless, Dr. Dahlquist has also stated that she is focused on making "distraction as effective as possible for children of different ages." The distraction capability of virtual reality was the lure for her. The use of virtual reality instead of standard electronic games allows patients to be fully immersed into a simulated world. Dahlquist has collaborated with the Believe in Tomorrow Foundation on a virtual reality study on pain distraction for use on children with cancer (Gengler, 2005).

During the development process for a personalized pain assessment and treatment plan, Dahlquist conceptualized using a virtual water world to test levels of pain in children. The idea is that both good and bad stressors intensify pain. In the water study healthy children were tested as well as sick children. Initial testing did not include any distraction while the children's hands were submerged into a tub of ice water. Average endurance was approximately 28 seconds. In the next test, the children's hands were submerged into the ice water as they watched a video of a person playing a *Finding Nemo* game. Average endurance rose to 34 seconds with this minimal level of distraction. In the third test, only one hand was submerged into the ice water while the free hand was used to play the *Finding Nemo* game. This time the average endurance time rose to 60 seconds and in several cases up to four minutes.

It has been found that children are more likely to benefit from virtual reality pain distraction techniques than adults (Gengler, 2005). Needless to say, this area demands further examination for both adult and pediatric groups.

Medical Education

Traditionally, anatomy is taught primarily through the use of detailed medical illustrations. Virtual reality can be used to explore the human anatomy at a level never before possible. It allows users to travel around the body by "flying" in, around and behind organs through the use of 3-D visualization. Virtual reality environments have been used in medical education for their ability to produce heightened understandings of the anatomy and relationships between different parts of the body (Riva, 2003).

Surgical Training and Assessment

Virtual reality applications for surgery can be lumped into three categories: surgical training, surgical planning and augmented reality. The role of virtual reality for surgery is radically different than those found in clinical and rehabilitative studies. One major difference is the use of immersive equipment like HMDs and data gloves. Immersive devices are used in more than 50 percent of virtual reality applications for behavioral sciences where only 20 percent of health care applications integrate this equipment. Virtual reality's role in health care is to present physicians and surgeons with virtual human senses that replicate the corresponding real-life sense. Virtual health care simulators should provide users with life-like body parts (or avatars) that imitate their real-life interaction capabilities (Riva, 2003). For instance, virtual organs should both look and feel real. They should rise and fall when touched. Shadows and highlights should reflect changes when the organs are handled and they should contract and expand when squeezed or cut. Low-resolution graphics limited early virtual reality simulators. Organs appeared geometric and elementary. They were not malleable like their natural counterparts. They did not offer input or feedback based on touch and feel. Improved next-generation simulators have found a home over these systems of the past (Riva, 2003).

Training and assessment is an important application of virtual reality in health care. It provides the opportunity for surgeons to practice hundreds of procedures prior to any patient contact. Walter Greenleaf, Ph.D., president of Greenleaf Medical in Palo Alto, said "it allows surgeons to learn invasive techniques before operating." Thanks to the help of robotics and 3-D visualization techniques, Minimally Invasive Surgery (MIS) has become the surrogate to open surgical treatments at an accelerated pace (Pueschel, 2004). Furthermore, the cost of traditional training resources like lab animals, cadavers and physician time can be reduced (Imaging online).

Historically, cost concerns and the medical economy have interfered in securing investments towards virtual simulation training. Only 20 million dollars is spent annually on the use of virtual reality for health care across the globe, and the U.S. Government spending is primarily funded by the military with an estimated $6 million a year. Nonetheless, the boundaries created by high-cost systems have been reduced over the past ten years due to a large price drop in computing products. The ongoing problem of cost restrictions within healthcare are being overcome through the development of products incorporating recently reduced desktop and Web-based solutions (Pueschel, 2004).

Part-task training is another alternative to high-cost virtual reality systems. The term part-task training refers to virtual reality products that break apart a total learning experience into several more manageable, cost-effective components. When training for only a portion of a medical procedure less computing power and money are required (Pueschel, 2004).

Virtual Presence, a London-based company whose medical division was later bought by the U.S.-based company Mentice, has developed a virtual simulator part-task training package that teaches the psychomotor skills required for laparoscopic surgery. It allows surgeons to practice the physical movements required for the surgery. Movements like cutting and lifting tissue or artery/duct clipping with an attached pair of standard surgical scissors are experienced prior to actual surgery. The participants' results are then measured against a database that evaluates these specific physical skills (Pueschel, 2004). These types of training products reduce surgical errors through repetition in a controlled environment and by providing timely feedback (Imaging online).

Another virtual reality simulator, The MIST® (Minimally Invasive Surgery Trainer) system, is a commercially available training and evaluation product also for psychomotor skills necessary to perform laparoscopic surgery (McCloy & Stone, 2001). This system uses abstract representations of laparoscopic tasks to do so. Residents who trained on the MIST system were able to perform the procedure 29 percent faster than those who did not. They were also less likely to injure the gall bladder or damage healthy tissue during the procedure than those with traditional training (Scerbo, 2005). It has also been found through controlled random studies that the MIST is able to discriminate between seasoned and inexperienced surgeons. Performance altering factors like alcohol levels and sleep deprivation can also be assessed (McCloy & Stone, 2001).

VIST® (Vascular Interventional System for Training, now made by Mentice), yet another virtual reality simulator, was developed by the researchers at the Center for Integration of

Medicine and Innovative Technology. It is used to train cardiologists on a stent placement procedure known for its complexity and high risk. The procedure is used to treat patients with plaque build-up in the carotid artery, which makes them high-risk stroke candidates. It improves blood flow to the heart through the placement of a stent into the artery. The surgery is difficult and only a limited number of cardiologists can perform it. The VIST system creates physical models of catheters and the vascular system which are used to simulate the appearance of what a cardiologist views on an X-ray display and can evaluate the competency of the doctor.

Evidence for virtual reality simulation as an effective form of training and skill assessment within the medical field was brought to the U.S. Food and Drug Administration (FDA) by Gallagher and Cates in March of 2004. The evidence was so strong that the FDA approved the carotid stent procedure with the inclusion of simulation-based training. Theoretically, physicians wanting to perform this procedure would need to prove their competency by meeting the criteria of an established simulator. Currently, a comparison study is in the works that measures the skill levels of virtual reality trained vs. traditionally trained physicians on the procedure.

For the first time in medical history competency will be measured based on performance and will be used to determine who can or cannot perform a procedure. It is also the first time that the FDA has specified how a patient must be treated. This event has triggered the consideration of virtual reality simulation as a viable means for training and assessment over a broad range of medical specialists. This represents a paradigm shift in how medicine will be taught and practiced in the future (Scerbo, 2005).

Surgical Planning

3-D Visualization, as used in medical education, is also used in planning surgery. Surgical planning is traditionally reliant on two-dimensional images, Magnetic Resonance Images (MRIs) and/or Computer Tomography (CT) scans. Surgeons study a series of scans and then have to translate them into three-dimensional representations mentally. This information is not easy to translate because complex anatomical elements are represented in different scanning models, on separate image series, often times found in different departments. The virtual reality simulator can bring all of these elements together by incorporating different scanning models from different sites into an easy-to-use interactive three-dimensional visual (Riva, 2003).

Cyberscalpel, developed by NASA researchers through the Virtual Collaborative Clinic, is a virtual reality system used to plan and practice surgery. The following is a sample surgical plan for a patient with jaw cancer. To plan this procedure visuals of the lower and upper jaws were reconstructed using the Cyberscalpel system. The reconstruction began with a traditional CT scan. The scan was reduced to 20,000 polygons and the model was then used to verify how the fibular bone could be sectioned to replicate and replace the pieces of the jaw (Riva, 2003). It is like a three-dimensional puzzle, fitting the pieces back together to form a whole. Examples of such surgical planning can be seen on the discovery television channel for various reconstructive surgeries.

Augmented Reality

Augmented reality refers to the idea that an observer's experience of an environment can be improved with computer-generated information. Usually this refers to a system in which computer graphics are overlaid onto a live video picture or projected onto a transparent screen as in a head-up display. In opposition to immersion therapy, the user in this case has one foot in the real world and one foot in the virtual world. Immersiveness is the key to treatment of mental health disorders with virtual reality, but this is not true for surgery. Rather than being totally immersed into an artificial world, surgeons who use augmented reality systems are not entirely divorced from the real world. The augmented reality system combines the real world scenes with the virtual scenes into a composite view for the surgeon. It is more complex than simply overlaying real world views with virtual images. The registration of the two must be exact and also maintained through the movement of the user during a procedure. Discrepancies in registration can warrant an entire system unusable (Vallino, 2002).

Augmented reality technology is extremely important in the medical field. It has been put to use in image-guided surgery and pre-operative image evaluation (like MRIs or CTs). Surgical planning is conducted from these images. Augmented reality makes the visualization of multiple images from multiple arenas easier and more accurate. Augmented reality technology makes it possible for surgeons in the operating theater to view MRIs or CT scans perfectly registered onto the patient during the performance of a procedure. The accurate registration of the images enhances surgical precision and eradicates the need for laborious, bulky stereotactic frames, a method used to immobilize target areas during surgery to ensure accurate registration (Vallino, 2002).

Telemedicine

The broad term telemedicine references the use of information technology in medicine. The area of telemedicine that extends into virtual reality is that of the telepresent doctor. The concept of telepresence allows doctors to treat patients from afar. Benefits include reduced medical costs and bringing medical expertise to remote locations. It allows surgery to be performed remotely to patients who do not otherwise have access to professional medical treatment (Imaging online).

Remote doctor-to-doctor and doctor-to-patient interactions are made possible through the use of video conferencing and robotics-assisted surgery. Canadian Surgical Technologies & Advanced Robotics (CSTAR) uses video as a primary role in performing minimally invasive surgical (MIS) procedures. Polycom, the company that produces the video conferencing system in use by CSTAR is the vendor of choice for the London Health Science Centre (LHSC) located in London, Ontario for video conferencing software for robotics-assisted surgery and remote discussions. Innovations in MIS such as these are important for two reasons; first, the use of robotics is more precise than the human hand and in turn reduces human error. Second, MIS is easier on patients. There are shorter recoveries and fewer complications with this type of surgery.

Telemonitoring and telesurgery, two applications that use the video conferencing software produced by Polycom allow CSTAR to teach MIS skills to surgeons remotely and also to perform surgeries and hold discussions thousands of miles away. With the Polycom video system, doctors are able to see each other and the patient over a video monitor. A camera is placed inside the patient and provides data to the system that can be viewed on screen remotely. The camera can be controlled by the remote doctor. This allows a more-experienced doctor to assist in surgery and give guidance throughout a procedure (Polycom.com, 2005). This is extremely beneficial since much of existing virtual reality research that has taken place in the medical field is concentrated on psychomotor skills. Few implement the cognitive skills found in experienced surgeons necessary for diagnosis, decision making, problem solving and case management (Scerbo, 2005).

Gaming

One would not expect healthcare and video gaming to come together, but these two industries have done just that. Most parents are already aware of the power video games have over a child's attention. Now the medical industry has recognized this potential for impact on patient care and for decreased costs related to medical technology. Needless to say, the use of video games for treating patients is growing.

Dr. Walter Greenleaf, a research scientist at Stanford University, has stated that many patients become bored with their treatments. Often patients lose interest or do not know what to do once they are sent home. In a response to his concerns, Dr. Greenleaf hardwired a glove for use as a video game controller for a rendition of the 1980s Atari space game, *Asteroids*, for patients who lost interest in physical therapy after a stroke. The object of the game is to shoot the asteroids that fly across the screen. In order to do so, patients must rotate their hand left or right to move the ship, and clench the fist to shoot. Although still in prototype, the game allows patients to perform the exercises without the movement becoming boring or mundane. This example is similar to that of a data glove.

Greenleaf reported that of 20 patients he sent home to perform exercises as treatment to physical ailments, 10 were equipped with the game and the others were expected to perform the normal exercises. The ones who had the game not only had good physical results but showed increased enthusiasm. Those without the game often became distracted or forgot the exercises entirely (Chaung, 2005).

Many of the virtual reality studies and software previously mentioned also consist of video game style graphics. Is this considered virtual reality or gaming? It is hard to differentiate between the two in some cases. There is a fine line between virtual environments and video game environments but one big difference is cost.

Traditional virtual reality systems are costly, sometimes in the thousands of dollars and often require funding. By treating patients with video games doctors are able to pull from existing resources such as commercial gaming solutions to save on costs. The October 2003 issue of *CyberPsychology and Behavior* published a paper that speaks to the effectiveness of treating individuals with phobias through the use of commercially modified computer games. By modifying commercially available computer video games, anxiety levels were heightened to a level required for phobia exposure therapy. Because of the low cost of video games, their modifiability and customizability for multi-player Internet use, and the ability to run on both Play Station 2 and Xbox platforms, the market is huge for this type of product (Berardini, 2003).

At the Virtual Reality Medical Center (VRMC), doctors use multiple video game solutions to treat patients with various disorders. They use *Midtown Madness*, a racing game, to treat patients who fear driving. In addition, they treat obesity or eating disorders in children with the *Sony Eye Toy* and dance and exercise games, like *Dance, Dance Revolution*. The goal of Mark and Barbara Weiderhold was to "get advanced technology to the hands of the clinicians for $300 or less" (Chuang, 2005).

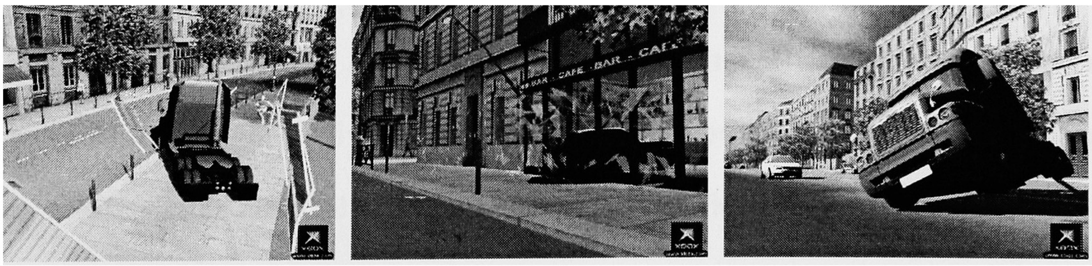


Figure 6: A series of screenshots taken from the video game *Midtown Madness*. (retrieved online at: http://www.xbox.com/en-US/games/m/midtownmadness3/)

An innovative game, released in 2003, called *The Journey to the Wild Divine*, produced by Wild Divine Project in Colorado, is used to aid in relaxation. Patients must control their breathing. Patients' pulse and body temperature are measured by biometric sensors that attach to the fingers. In order to move, deep breaths are sometimes required. Other scenarios require a patient to laugh or shout, or to keep three balls airborne to release energy. The game helps patients relax or calm down when they are stressed, especially children who are often unable to become calm on their own. The game guides them through the process. Additional research is taking place to see how the game may be used in the future treatment of patients suffering from migraine headaches, autism and obesity (Chuang, 2005).

Figure 7: A series of screenshots taken from the video game *The Journey to the Wild Divine*. (retrieved online at: http://www.wilddivine.com/JourneytoWildDivine/)

In conclusion, these newly adapted virtual environments are a simple, cost-effective alternative to case-specific virtual reality equipment. The entire system is only a few hundred dollars, compared to thousands. Additionally, graphics are extremely realistic and systems are easily modifiable to combat individual patient fears. Moreover, off-the-shelf HMDs and head-tracking devices can be included to create added immersion (Knight, 2003).

An Overview of the Different Methodologies

The nature of product development is far-reaching. Rather than approaching projects unarmed, practitioners have found creative ways to develop usable solutions. A combination of similar, yet different techniques that have alleged success in application design has been instituted. The outcome and the user-centered design methodologies are as follows:

1. Contextual Design
2. Learning Centered Design (LCD)
3. Participatory Design (PD)
4. Performance Centered Design (PCD)
5. Scenario-based Design (SBD)
6. Usability Engineering (UE)
7. User-centered Design (UCD)

Each of the above techniques has similar qualities but is applied to every project uniquely and warrant different results.

Contextual Design (CD)

This methodology is "a customer-centered design process guiding a team from initial data gathering to system design." CD is a gross collection of customer data through techniques that focus on the ultimate goal of understanding how the end user works. CD is best facilitated when the opportunity for direct access to users is available. It incorporates the following steps; 1) contextual inquiry, 2) work models, 3) consolidation, 4) work redesign, 5) user environment design and 6) mock-up and evaluation (Beyer & Holtzblatt, 1997).

Learning-Centered Design (LCD)

The general definition given to LCD is "a design approach aimed at developing software to support learners via scaffolding as they try to work in and learn the given work domain" (Quintana, Krajcik & Soloway, 2003). LCD is the fusion between guided support and the empowerment of the user, which allows the learner to be taught new skills and ideas (Hsi &

Soloway, 1998). The strategy is called scaffolding. The strategy, scaffolding, refers to the backbone support system, similar to that used in building construction, which LCD provides to the learner in the development of new work practices.

Participatory Design (PD)

Different communities of practitioners have different definitions of PD. Therefore, it is not as cut and dry as the other methodologies on the list. More than one school of thought exists but there is a common theme throughout. The collective idea between the various schools of thought is that the end-user must participate throughout the entire development process, beginning with requirements gathering through implementation. The following supports some of the more recent definitions:

1. "Participatory design (PD) is a set of theories, practices, and studies related to end-users as full participants in activities leading to software and hardware computer products and computer-based activities" (Muller, 2002).
2. "Participatory Design (PD) is a set of diverse ways of thinking, planning, and acting through which people make their work, technologies, and social institutions more responsive to human needs" (Trigg & Clement 2000).
3. "An approach to the assessment, design, and development of technological and organizational systems that places a premium on the active involvement of workplace practitioners (usually potential or current users of the system) in design and decision-making processes" (Trigg & Clement 2000).

Performance-Centered Design (PCD)

"Performance-Centered Design is a technique that utilizes iterative cycles of rapid prototyping and software design activities that include collaboration with actual performers.

These activities result in robust interfaces that generate desired business outcomes via direct support for performers" (Ariel, 2006). This software development methodology involves the inclusion of the end-user's perspective as well as the integration of this perspective into the overall design philosophy. The goal of PCD is to ensure that the software developed is completely intuitive, requiring no additional training or instructional guides. This is achieved through an understanding of the end-user's work model and designing software to compliment this style by incorporating metaphors and language already in practice, rather than defy it. Naming conventions and instructional wording for the user interface are scrutinized in the PCD methodology. Intuit's Quicken software, often sited for its superior design, is a PCD application. The reason for its superior status is its wide-range of support for users of varying degrees of skill, from novice through expert. A first-time user can use Quicken without feeling frustrated (Marion, 1997).

Scenario-Based Design (SBD)

The focus of SBD is on a situation and all of its components including the stakeholders, environment and objectives. These components are determined through detailed descriptions of how users complete tasks. These descriptions provide the framework for the working design models in SBD (Carroll 2000, p 45). In particular, both the critical and typical tasks that people are required to perform in order to do their jobs are identified, and design trade-offs are established that need to occur to facilitate these actions (Rosson & Carroll 2002, p. 359). There are five basic elements that make up SBD. The diagram below summarizes these.

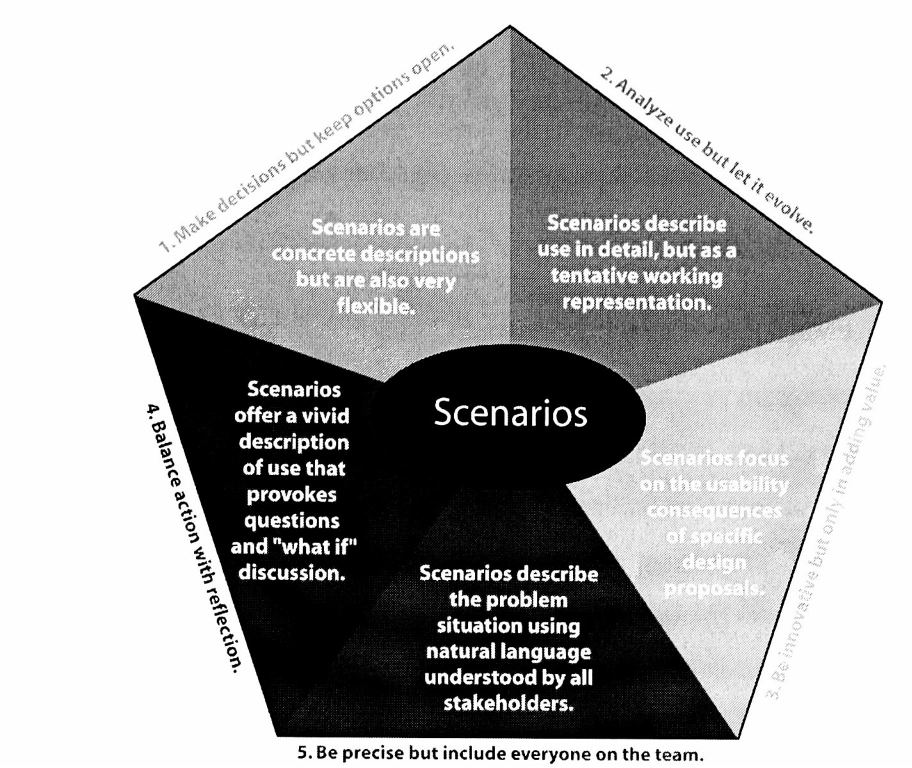


Figure 8: Five Elements of Scenario-Based Design (Rosson & Carroll 2002, p. 21)

Usability Engineering (UE)

UE is a multidisciplinary field stemming from human factors engineering (HFE) into computer systems design. Most often applied to software engineering projects, its science is based mainly in the experimental psychology of human information processing (Butler 1996, p. 61). It is also defined as a "discipline that provides structured methods for achieving usability in user interface design during product development" (Mayhew 1999, p. 2). Taking place throughout the project lifecycle, UE is unlike usability testing. During UE, vital activities take place in the very early stages of development, long before the design of the user interface (Nielsen 1993, p. 1).

User-Centered Design

Generic in nature, UCD finds multiple schools of thought within the industry associated with it. One school of thought is that of a generic umbrella, which refers to all of the other user-oriented design methodologies previously discussed. In its generic form, UCD is the standard for all product development methodologies. Through an in-depth understanding of the UCD method and various UCD techniques, one can begin to see the reason for the overlap between the other user-oriented design methods aforementioned (Vredenberg, Isensee, & Righi 2002, p. 20). The generic definition of UCD is:

> " a highly structured, comprehensive product development methodology driven by (1) clearly specified, task oriented business objectives, and (2) recognition of users needs, limitations and preferences. Information collected using UCD analysis is scientifically applied in the design, testing, and implementation of products and service. When rigorously applied, a UCD approach meets both user needs and the business objectives of the sponsoring organization" (Keller et al. 2000).

In conjunction with the generic approach, an integrated approach has been established, which differentiates UCD from the other user-oriented design methods. The integrated definition is as such:

> "[designing] ease of use into the total customer experience with products and systems. It involves two fundamental elements: multidisciplinary teamwork and a set of specialized methods of acquiring user input and converting it into design" (Vredenberg, Isensee, & Righi 2002).

This integrated approach encompasses the entire user experience not just the interaction between the end-user and the software. It is initiated the first time the customer sees a product or service advertisement through to the upgrade to a new version of software. It begins at software acquisition and continues through to software maintenance. The entire time keeping the end-user in mind (Vredenberg, Isensee, & Righi, 2002, p.20).

The Techniques

User-centered design (UCD) surfaced as a solution for creating useful and usable products. It is a widely accepted methodology for the production of functional software applications that accurately meet the needs of the end user. Whether your task is a new product initiative, the evolution of an existing product, rewriting an application user-interface (UI), or selecting an off-the-shelf solution, the employment of a UCD process will improve the end result.

UCD activities are introduced at project inception and continue through project completion, essentially the entire development lifecycle, from initial requirements gathering through prototyping and testing. A set of core design activities is loosely followed when applying a user-centered design methodology to a specific domain. The following table is an overview of these core design activities involved in the development process (Scanlon & Percival, 2002).

Activity	Description	Phase	Purpose
Audience Definition	Analysis of user roles and user characteristics relevant to UI design	Requirements & Analysis	To understand specific user attributes that may need to be accommodated in the UI design; to determine how these attributes may differ across user roles; and to select participants for usability evaluations
Task Analysis	Analysis by user role of important tasks to be performed by target users	Requirements & Analysis	To understand how users will use the system to accomplish their task goals, and to determine how these tasks may differ across user roles
Heuristic Review	Expert evaluation of the usability of predecessor and/or competitor applications based on usability & UI design rules & principles	Requirements & Analysis	To determine areas of the predecessor UI needing usability improvements; to evaluate competitors' strengths and weaknesses; to establish usability goals for

			the future system
Use Case Model	High-level, design-free 'use case' descriptions of human-computer interactions (HCI), composed into a model of the relationships among use cases	Requirements & Analysis through Design & Development	To understand for each task the step-by-step interaction between user's intentions and system responsibilities to accomplish the task goal, and to understand the relationships among the task-specific use cases
Iterative Design	Low-fidelity and high-fidelity UI prototypes, iteratively re-designed based on user feedback	Design & Development	To elicit user feedback based on simulated task performance using a series of low-fidelity/high-fidelity prototypes, in order to optimize the usability of the UI design
Design Specification	Comprehensive, detailed documentation of the UI design; can include a Visual Design Guide	Design & Development	To provide development with detailed descriptions of all aspects of the UI, from navigational behavior and screen layout, down to the level of UI object attributes
Usability Validation Test	Formal usability test of target users performing important tasks using stable system test application code	System Test	To determine the usability of the system, to validate against usability goals, and to set benchmarks against which to measure the usability of future releases

Table 1: Core Design Activities in the Development Process

Establishing usability goals for software applications often involves a heuristic evaluation. The heuristic evaluation is used in addition to quality testing. It serves as a starting point for determining product deficiencies, whether these are predecessor, current, or competitors' products. Following a set of design guidelines, software is evaluated to determine ways to make it more useful. There is more detail on heuristic evaluation provided later in this chapter. (Desurvire, Caplan, & Toth, 2004).

Define Audience

Understanding the user is the first step in the analysis process. Who is the end user? What will they use the product for? Defining a target audience is important because it identifies various user traits that need to be accommodated for in the design, such as level of experience. Is the user a novice or expert? Conclusions made during the analysis phase of a project should direct design decisions. For instance, if a large population of the users are inexperienced, the design may support this by providing an easy-to-learn interface rather than focusing on high-efficiency for expert users. A child's needs are going to differ greatly from adults. Different skill levels, such as reading levels need to be accommodated for.

For users apprehensive of new technology, traditional classroom training may be the answer as opposed to extensive online support and do-it-yourself tutorials. The point to remember is that the application should support the users' needs and enable users to perform their tasks quickly and successfully (Scanlon & Percival, 2002).

Task Analysis

As important, if not more, than defining the user is performing a task analysis. The emphasis of the task analysis is on how the software is going to be used. This includes not only understanding how the users currently accomplish their work but also how their work flow can become more efficient. The tasks that are supported need to be understood as well as who is performing them. The analysis of user roles helps us understand what tasks are currently being performed as well as how they are performed. Our examination should extend beyond who does what and how it gets done though. This data should be scrutinized to determine areas of inefficiencies and new ways to increase productivity. One example of enhancing user performance with software would be the inclusion of drop-down menu style selection list to reduce redundant and time consuming data entry that can cut into project completion time (Scanlon & Percival, 2002).

Heuristic Evaluation

As mentioned earlier, heuristic evaluation is a supplemental method of evaluating the usability of past, present and competitor products. More than one team member is involved in the evaluation that follows a recognized set of user-interface (UI) design guidelines. Most often the interface of the product is the main area of scrutiny. Since this method of evaluation is used in conjunction with a multitude of other testing options it does not involve the level of formality that the others require. Because of the informality of heuristic evaluation it is more cost effective. It does not require high-level experts to be effective. Although, the likelihood of locating major design problems is higher in heuristic evaluation than finding minor ones (Nielsen, 1992). The more obvious design problems are easier to spot with heuristic evaluation than those that are not as prominent and may require digging deeper into the software application. This is where other more formal evaluation like quality testing are useful.

Usability as defined by ISO (ISO 9241-11) includes three major parts: (1) effectiveness, (2) efficiency and (3) satisfaction. Effectiveness refers to the level of accuracy and completeness that users are able to perform tasks. Efficiency encompasses the resources needed to provide the most correct and complete final product. And lastly, satisfaction involves the users' attitudes towards the software and their comfort level when using the product to perform their task. These three factors can sometimes be difficult to gage when evaluating software interface design and therefore an alternate definition may be, the absence of obstacles when completing a task (Skov & Stage, 2005). The opinion of what is good and what is bad about an interface determined through the heuristic evaluation is later used to direct the new design or improve an existing design.

Use Case Model

The use case model describes the contact between human and computer. It looks at how the user is interacting with the computer system to accomplish his/her tasks. The aforementioned audience definition and task analysis contribute to the development of the use case model. One constituent of creating a use case model is a chronicle of the user interaction, a story of how the user is interfacing with the product to get work done. Preliminary use case studies that include these descriptors should be completed before any UI design takes place. The absence of design is intentional at this point. This portion of the use case model is an abstract model of how the system is used to accomplish a task. This is known as an essential use case, as defined by Constantine and Lockwood. Overall, an essential use case includes a well thought-out narrative about the user role in completing a task. The description is free of any technology or design implementation and remains abstract in this beginning stage.

Constantine and Lockwood also propose a change in our thought process from user action and system response to user intention and system responsibility. This better describes what the software design needs to accomplish. The user's intention is to complete a task and the responsibility of the system is to carry out the action required to help them do so. In this early stage the system lacks definitive responsibilities or requirements. The responsibilities of the system will be more clearly defined during the low-level system design phase (Scanlon and Percival, 2002).

Iterative Design

Once all of the analysis and modeling is complete the actual design process begins. Nonetheless, this early design stage is still far from its final juncture. Much of the design work produced during the iterative design phase is thrown away. This is due to the use of prototyping in varying degrees, from low-fidelity paper and wire prototypes to high-fidelity interactive simulations. These prototypes are used to gather user feedback quickly and frequently to produce a more usable product. The level of design that is supported at this stage comes directly from the use case models. The prototypes are planned around the tasks that were determined for each use case. User feedback is a requirement during software development in order to accurately meet user needs. It is unlikely that even a seasoned designer equipped with all of the correct information in its entirety would be able to create a fully usable design at the outset. Several iterations are necessary to produce a software application that performs both effectively and efficiently. Instead of programming the software and waiting for completion to test, easily modifiable prototypes allow developers to quickly construct low-end product models and for these models to be tested prior to product completion. Testing often limits design flaws by catching them early on. Most frequently, high-level design inconsistencies and incompatibilities are addressed in this early design stage such as navigation and over-all screen layout. Later, using more high-fidelity prototypes, more low-fidelity design issues will be handled through the completion of a usability evaluation (Scanlon & Percival, 2002).

Design Specification

Usually, at this stage, regardless of whether or not a high-fidelity prototype exists, only core application requirements are secured. A number of low-level elements still remain, like error handling, messaging, and online support, and demand further detail. These low-level design elements need clarification in order for the programming of the UI to begin, hence the importance of the design specifications document. The task-oriented prototype is useful for demonstrating and simulating the completion of a task, the design specification of the UI focuses on the critical areas of functionality such as screen display, window menus and pop-up dialog boxes. During the specification process each attribute of the UI is defined and documented in detail down to the properties of each and what field they are to appear in (Scanlon & Percival, 2002). Again this is a very low-level process which prevents the former iterative design from being fully comprehensive at its early stage.

The design specification document is equivalent to an architect's blueprint. It serves the design team with very specific low-level details needed to complete the design, such as font and type size, what will each objects behavior be (what outcome will clicking a button produce), error handling, accompanying error messages and selection status, like selected, rollover, or not selected, and the look of each of these conditions (Vredenburg, Isensee, & Righi 2002).

Usability Validation Test

A formal usability test can occur once the program is fully coded and the system test is in progress. The three-fold process items are (1) how usable the product is, have all usability requirements been met, are there any remaining usability issues and can these issues be dealt with during the training period, or can they become part of a next-generation product release or serve as a standard of measurement for future product releases (2) how quickly a task can be completed, how accurately it is completed, and how many and how often do errors occur during task phase and (3) subjective outcomes, like user satisfaction, are also measured. Such subjective measurements can be obtained through positive or negative comments provided from test participants. All parts of the final deliverable should be available to testing subjects at this late development stage (Scanlon & Percival, 2002). Measuring both user and product performance in ways that allow statistical comparisons to be made and conclusions to be formulated serve as benchmark assessments for future product iterations (Vredenburg, Isensee, & Righi 2002). Figure 9 on the following page can be used as part of the usability test to gather ease-of-use information from participants based on itemized task completion.

Task satisfaction:
Ease of completion

Task	Mean Curr	Mean Fut
1. President and CEO	5.8	6.0
2. More about the company	4.2	5.9
3. Firewall info	5.8	6.2
4. Services for company's new hardware and software.	4.0	2.8
5. Visitors download which files	4.0	4.8
6. Press releases	6.5	6.0
7. Send info to your e-mail address	4.3	6.0
8. Open an account	6.5	4.5
9. Send your resume	5.0	6.5

1= Strongly Disagree, 7 = Strongly Agree

Figure 9: Survey Example (Vredenburg, Isensee, & Righi 2002, page 155)

In order to perform a usability test one must first design the test and select the participants to take part in the test. These variables can hugely affect testing outcomes if not performed correctly. The purpose of the test is important to ensure the appropriateness of the test design. All instances to be tested must be controlled in order to allow each condition to be measured for results.

A list of things to keep in mind when designing a usability test is:

- The goal of the test
- Number of participants and descriptions of these participants
- Testing schedule
- Testing method

- Tasks to be completed
- Measurements to be made
- Data analysis techniques
- Reporting methods and actions required based on findings

Oftentimes a usability lab is employed to ensure optimal testing conditions. Such a facility may include a secluded testing room with cameras, as well as a separate observation room for viewing participants during the test. This is not required though (Vredenburg, Isensee, & Righi 2002).

Selecting participants that are right for the test is fundamental to obtaining accurate results. If your test is designed to understand the performance of the general public, subjects with varying skill levels and characteristics should be included to represent the desired population. Alternately, if your focus is on novice users, users with little to no computer experience should make up your test group. Most often, product tests are performed to meet the requirements of the specified domains that they were developed for. Consequently, if a product is developed for use in banks, test subjects should have prior banking experience. This provides observers with valuable feedback needed for future product improvements rather than responses that are not qualifiable given the users lack of experience in banking activities. They would not be considered part of a relevant user population for this given product.

Groups with mixed skill levels are more desirable when conducting usability testing because they help eliminate the errors that may occur with novice users, unless novice use is the purpose of the test as stated earlier (Vredenburg, Isensee, & Righi 2002). Test groups containing three to five participants have been found to warrant the most statistically relevant results (Neilson & Molich, 1990). Smaller classes tended to be influenced by the other subjects and larger groups have to widely varying outcomes that were too varied for measuring. Also, be mindful of the effects that using the same participants for more than one test factor can have. It can lead to more efficient test results but it can also present the possibility for results to lean a certain way that users may be partial to (Vredenburg, Isensee, & Righi 2002). Nevertheless, selecting appropriate test subjects is crucial to obtaining constructive feedback. All others can be considered a waste of precious development schedule time.

This section is an overview of the activities involved in applying a user-centered design approach to a software development project. Project type should not determine the use or non-use of a UCD. A liberal amount of projects can benefit from the application of this methodology. When a user-centered design approach is applied to a products development cycle the end result will be a more usable design regardless of the nature of the project.

The simple goal of UCD is to provide products that are easy to use. As revealed in this section, making easy to use products is not an easy job. It takes a lot of hard work from a lot of people. The addition of this work to a design project is the difference between awkward, difficult to use products, and efficient, usable products (Vredenburg, Isensee, & Righi 2002).

The remainder of this paper will focus on leading a design team through a virtual environment software development project where specific methodologies are applied to achieve optimal results.

Summary

As discussed throughout this section, virtual reality is swiftly expanding beyond the realm of entertainment. Researchers throughout the clinical and medical fields have recognized its potential in treating a variety of problems. From mental health disorders to performing medical procedures, virtual reality is revolutionizing patient care and testing the next generation of innovations with video environments used in gaming and robotics. The growth that virtual reality has seen in the past decade is minimal compared to what lies ahead in decades to come. There is more and more research available towards the use of virtual gaming environments as a cost-effective alternative to traditional virtual reality equipment.

So where are human factors in all of this? There is no question that this aspect is largely missing from existing designs. Moreover, the human factors community seems generally unaware of advancements in the clinical and medical fields with regards to virtual reality software development. In fact, for both MIST VR and VIST VR simulator systems mentioned earlier there were no human factors designers on either development team (Scerbo, 2005). With so much happening with virtual reality software development in both mental and medical health fields, new approaches to design need to be introduced. A definite addition to the current product development should be human factors. The next generation of virtual reality software products will need to accommodate more advanced users. This is where human factors specialists can help. Experts in the human factors field have pervasive knowledge on cognitive task analysis and engineering, intelligent interface design and automated systems (Scerbo, 2005). Interfaces will need to become intuitive and memorable for the technology to continue moving forward. Virtual reality software products that encompass the entire user experience will need to be available rather than products guided strictly by specifications only (Swartout & van Lent, 2003). The point to be driven home is that without human factors designers involved in future products, the software will not offer any more than it does today. Growth will slow and the full potential of non-entertainment virtual reality products will not be realized. There is a huge opportunity to bridge the gap between science and technology with the methods of the human factors profession (Scerbo, 2005). The intention of the remainder of this paper is to focus on the step-by-step process of creating a product that focuses on the entire user experience through the application of a user-centered design methodology through working with a team of human factor specialists and show the results. In the sections to follow an in depth analysis will unfold.

METHODOLOGY

A case study will involve applying a user-centered design technique throughout the development of a virtual environment software application that will be used to treat returning Iraqi service men and women with PTSD symptoms. The reason that a virtual environment software application was chosen was to keep the focus of the project on the user interface and move away from heavy head gear and other cumbersome virtual reality equipment. The virtual environment is the logical choice because it is largely screen based as opposed to virtual reality software that does not incorporate the use of the computer screen and still relies on heavy external gear to accomplish tasks. Since this scenario does not take place in a typical office setting, access to actual users is not available. If access to users were available the preferred methods for gathering requirements would be a combination of user-centered design (UCD) and contextual design (CD) methodologies. The use of these techniques would involve gathering information through observation and interviews, contextual inquiry, work models, and interpretation sessions. With that being said, upon completion of an extensive literature review the actual methodology that will be applied to this particular project will be scenario-based design (SBD) (Rosson and Carroll, 2002). SBD is a waterfall method that utilizes a series of rapidly created scenarios. Without actual user involvement, SBD was the best choice for the given problem because it allows for a rich and evocative design representation that the entire development team, lead by a software engineer, can contribute to while remaining cost-effective. It can also be evaluated and revised quickly if need be (Rosson and Carroll, 2002).

The case study will allow for written exploration of many of the various SBD approaches. A typical software development lifecycle will be revealed through the development of user profiles by the completion of a user and task analysis. The skill-set and physical constraints of the audience will determine the capabilities needed to function within the virtual environment. The system will need to include alternate options for those who are hearing impaired such as caption selection rather than sound and audio. There will also be limitations on those who cannot use the software effectively, for example, people with eyesight impairments.

The following stages of SBD will aid in the development of an immersive virtual environment that will include realistic computer graphic images, real time response feedback and lifelike audio. The software will allow patients to relive their war experience and provide an outlet for various wartime scenarios to be recreated in a make-believe Iraq. By confronting a make-believe Iraq, patients will be able to assert better control over their memories. The intent is to stop nightmares, outbursts of aggression and other readjustment issues that afflict many returning Marines, soldiers, and sailors (Dotinga, 2005).

The Stages of Scenario-Based Design (SBD)

Analyze Requirements

The initial stage of SBD is the gathering and analyzing of user requirements, beginning with a mission statement that will be revisited as the project unfolds and more specific information is obtained. Following the mission statement the root concept will be developed that contains both the high-level vision and the basic rationale for the project during this early stage. Determining who the users are is one of the first questions that needs to be answered when beginning a new design project. The stakeholders are determined and analyzed early on to ensure that the software being developed meets all of their needs. The profiles of the different stakeholders are required to determine what activities need to be studied. Each will be impacted differently and their unique motivations and problems need to be satisfied. Most often the stakeholders are unable to adequately communicate the perspectives of others involved and it then becomes the task of the design team to filter out the necessary information. Posing questions and determining the requirements based on the answers provided can accomplish this. This interviewing process, along with observation, used to probe the stakeholders' unconscious is part of the initial requirements gathering stage called contextual inquiry but will not be used for this project. The reason for its omission is the lack of user access (Rosson and Carroll, 2002).

In a waterfall system requirements are not gathered all at once. However, this initial requirements gathering is needed to get the project started. Ideally a field study would be conducted, where the workplace is observed and user-interaction scenarios are formulated. Once the study is completed summaries about the activities can be made (Rosson and Carroll, 2002). Regrettably, this project does not lend itself to either as there is no access to an office setting or workplace to study. Without a field study, the requirements for this project will be determined from the information that was obtained through the literature review that precedes this section.

Once the user analysis, the basis of which was formed from the information unearthed in the literature review, including user profiles and task analysis, is complete the problem scenario is developed. This is still part of the analyzing requirements stage. The problem scenario tells the story of the current practice. It is a creative activity that incorporates the various stakeholders in a story. If all or some of the stakeholders are unknown a hypothetical group of stakeholders can be used (Rosson and Carroll, 2002). For this project a hypothetical group will be employed to complete the case study. The foundation for determining the hypothetical group is based on knowledge obtained through the in-depth literature review that has been completed. It will include hypothetical people with characteristics typical of a stakeholder group. The stakeholder groups are determined by narrowing down the most important players, those who have a vested interest in the success of the product. For this project the information necessary for determining these groups will be deduced from the content found in the literature review. These stakeholders will serve as actors in the problem scenarios, and the background and motivation for each will help to imagine how a specific scenario might unfold from that person's perspective.

For this case study, the problem scenario will describe a therapy session prior to virtual reality technology. In this exercise the activities in the problem subject are spelled out. With SBD, all new activities stem from current activities, therefore it is necessary to understand your problem domain thoroughly. This allows for a claims analysis to be worked into the scenario in which different trade-offs are compared. The good and bad features of the system are documented to determine areas of concern. Claims features, or objects that notably affect the user's experience are analyzed throughout the development of a new system (Rosson and Carroll, 2002). One example of a claims feature found in this case study will be different types of sounds and audio proposed. Each will be analyzed to determine their appropriateness to the situation.

Activity Design

Designing the systems functionality is the next stage in the SBD method, called activity design. During this first phase of the design rationale the goals of the systems functionality will be defined. Both problem areas and areas of opportunity are considered and new ways of executing tasks are introduced. These basic concepts and services of the new system are described here. The functionality of the system will set up all the possibilities for the new application. The user never sees this back end functionality. It is the interface that the users will eventually interact with, that will determine what they need to do to experience all of the systems possibilities (Rosson and Carroll, 2002).

A cooperative design approach would be an ideal practice for this project because it allows for collaboration between designers and perspective users throughout the entire life of the project beginning with requirements gathering. This interaction promotes mutual learning and aids in gaining project acceptance, which is invaluable when introducing new technology to people (Rosson and Carroll, 2002). For the case study that follows cooperative design is unrealistic because of a lack of user access. The approach that will be used for this circumstance is activity design. This alternate approach is appropriate because it permits developers to focus on users current tasks and allows for the implementation of the smallest change all the way up to incorporating new and innovative technological solutions that users may not know about (Rosson and Carroll, 2002).

Along with writing scenarios and claims to document and share design models, technical representations such as feature lists, task analyses, data-flow diagrams, or object-action tables can also be used express ideas (van Harmelen, 2001).

Information Design

The information design stage allows for user perception and interpretation of proposed interface designs. The user is involved in interpreting the visual cues of the layout and deciphering what to do with each. A gap in what is displayed on screen and what a user's interpretation is of an on-screen element is referred to as the "Gulf of Evaluation." An example of the "Gulf of Evaluation" is represented in the top half of figure 10. The goal of a system design is to close this gap by creating an interface where the information provided is easily interpreted by the user. Sample application screens, menus, dialog boxes and icons that incorporate the principles of Gestalt will be represented in this section of the case study. Gestalt principles, developed in the 1920s by a group of German psychologists, serve as the foundation of perceptual psychology and have found their way into information design. Incorporating Gestalt principles into the visual organization of an interface increases the users' understanding of the application. For example, arranging elements in close proximity to one another allows them to be viewed as a group. Such simple concepts can change the perception of an interface. More Gestalt principles and user interface examples of each are represented in Table 2. Traditional graphic design combined with interactive information design help make the visual design of the system a reality (Rosson and Carroll, 2002).

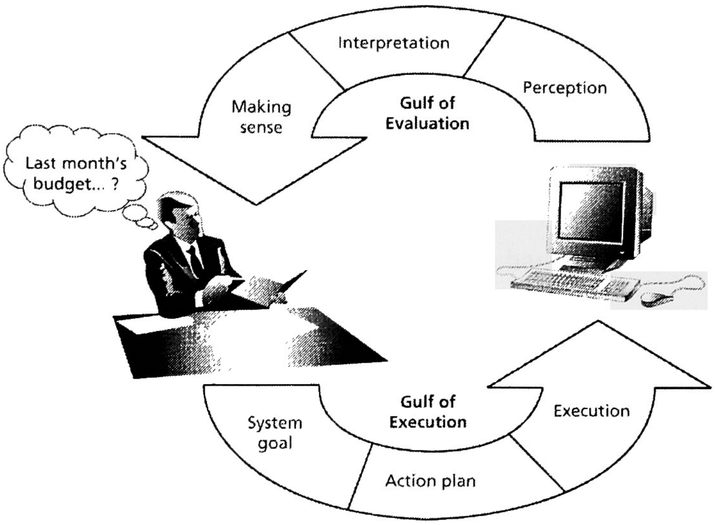


Figure 10: The Gulf of Evaluation in human-computer interaction (after Norman 1986).

Gestalt Principle	**User Interface Examples**
Proximity: elements near each other tend to be seen as a group	Words on a menu bar, columns in a tabular display, text in a paragraph
Similarity: elements that share visual characteristics (shape, color, etc.) tend to be seen as a group	Toolbar icons (proximity operates here as well), data visualization
Closure: there is a tendency to organize elements into complete, closed figures	Overlapping windows, menus, dialog boxes and other user interface controls

Gestalt Principle	**User Interface Examples**
Area: there is a tendency to group elements in a way that creates the smallest possible figure	Icons on a workstation screen, pop-up menu on top of a document display
Symmetry: there is a tendency to see symmetric elements as part of the same figures	Window manipulation controls (e.g., scroll bar, selection handles)
Continuity: there is a tendency to group elements into continuous contours or repeating patterns	A page of paragraphs, a grid of spreadsheet cells, a left-justified list of selections or parameters

Table 2: Gestalt principles of perceptual organization that aid perception of user interface visual elements (Rosson and Carroll, 2002).

Interaction Design

Interaction design is different from information design in that during the information design process the type of objects and actions are determined and during interaction design, it is the job of the designer to make sure the user knows what to do with the object and when to do it. For example, the affordance of a door lets a person in, that is what users are looking to do when they approach a door, enter a space. They look for the handle and determine how to use it based on their past experiences with doors in the real world. Sounds simple, but the usability of even everyday items can be hindered by poor design. Icons and graphics that are not intuitive can lessen the usability of an application. The simplest case is one where the virtual object mimics that of the real world object, like the trash can symbol used on a Microsoft Windows® desktop. Language can also play a big factor in the usability of an application. If the language chosen to name objects is complex or too lengthy it will make navigating the system difficult or impossible for the user (Rosson and Carroll, 2002).

Prototyping

In the next stage of SBD, called prototyping, a mock-up of the system design is created. It is this partial implementation of the system that helps designers resolve unanswered questions, refine user requirements, and explore remaining design ideas. Prototypes allow the design team to further develop design ideas in collaboration with actual users. The user testing that occurs during the prototyping stage provides valuable feedback that is then used to qualify the current product and/or further enhance its usability through the implementation of the users comments (Rosson and Carroll, 2002). There are many different types of prototypes that usability engineers have to choose from. It is the responsibility of the usability engineer to choose the one that is the best technique for the given project. Table 3 shows a representation of the different prototyping approaches and a description of each.

Type of Prototype	**Description**
Storyboard	Sketches or screen shots illustrating key points in a usage narrative
Paper or cardboard mock-up	Fabricated devices with simulated controls or display elements
Wizard of Oz	Workstation connected to invisible human assistant who simulates input, output, or processing functionality not yet available
Video prototype	Video recording of persons enacting one or more envisioned tasks
Computer animation	Screen transitions that illustrate a series of input and output events
Scenario machine	Interactive system implementing a specific scenario's event stream
Rapid prototype	Interactive system created with special-purpose prototyping tools
Working partial system	Executable version of a system with a subset of intended functionality

Table 3: Common approaches to prototyping (Rosson and Carroll, 2002)

Two types of prototype will be used for this project; the storyboard approach and the scenario machine approach. The storyboard or user interface prototype will consist of a dummy interface that has been sketched to mimic the actual screen that could be viewed in the virtual environment. The storyboard approach was chosen because it a cost-effective solution that can be produced quickly and altered just as fast. It allows developers to visualize a solution on paper with a rough sketch and get immediate feedback from users and quickly revise the sketch to incorporate that feedback. This process can occur multiple times in a relatively short period of time in order to get the best results, rather than building something out that requires both time and money and will not likely be the best solution on the first try.

The scenario machine approach was chosen for this project for its ability to depict a user scenario as a sequence of events. For this project a street scene in Iraq will be used to demonstrate this approach.

Usability Evaluation

Usability evaluation is an analysis of the prototype. Evaluation is an important step in gathering user feedback at certain critical stages of development. Once the problem is identified it can then be addressed. A usability evaluation will not be executed for this project, as there are no users to test the prototype. Simple sketching of the screens does not allow for such an elaborate analysis phase (Rosson and Carroll, 2002).

User Documentation

User documentation is very important as it serves as the "bible" for the system. It houses all of the information on how the system is used. A typical format for the user documentation is a bound reference guide, although user tutorials and other electronic information can be part of the documentation also (Rosson and Carroll, 2002). The following case study and appendix sections will serve as this projects documentation.

Summary

The components of SBD describe the design approach that will be applied to this case study. The application of various SBD techniques through a case study provides an organized document that details the specified problem. By employing many of the SBD techniques, the end product will have increased usability based on the exploration of user requirements. The main goal is to improve the current practice by implementing proven usability tools that are accessible to any software design team to help increase product usability.

CASE STUDY

How can applying scenario-based design tools and techniques improve the user-interface design of a product? This case study applies scenario-based design tools throughout the development of a virtual reality software product that will be customized to incorporate diverse virtual environments to aid in the therapy of Iraqi veterans suffering from PTSD. The main purpose of this study was to illustrate how to take a software development team from start to finish using user-centered design techniques as tools to improve a user interface. The target audience was post-war veterans that served overseas in Iraq and PTSD therapists that work with the veterans upon their return to alleviate symptoms of PTSD using virtual reality therapy. Current virtual environments interfaces were examined and revised to meet the specific needs of this target audience.

Purpose

The purpose of this study is to develop a virtual reality software product that will supplement standard talk therapy for PTSD therapists and post-war veterans suffering from PTSD, through the use of scenario-based design tools and techniques that are centered on the user interface. The more seamless and easily navigated the interface design, the higher the likelihood of increased patient immersion. The hope is that by increasing patient immersion through an improved user interface, alleviation of their frustrations and nightmares can occur. By using SBD techniques to improve patient immersion through an improved user interface it is believed that a superior product will be created.

Requirements Analysis

A typical requirements analysis involves people who are using current technology. These users describe their practices with the current technology and base their new requirements for what subsequent technology may offer and what is appropriate. Typically users would be interviewed about their practices or a work situation would be recreated and the users observed to gain insight into their requirements. An additional method that can be used is brainstorming. The brainstorming approach was chosen for this project. It is appropriate because it allows developers to come up with possible scenarios for the system by speculating what the user need is to perform a given task and assessing how the user will interact with the system. Although this method is not as open to users' immediate needs it does allow for the discovery of less obvious needs that are not apparent in an actual work situation (Turner, 1998).

Mission Statement

The exposure therapy will allow veterans to relive their trauma through the creation of a make-believe Iraq. Scenarios and sounds from Iraq are recreated in a virtual environment to help the user regain his/her confidence through constant exposure to high-anxiety stressors in order to better cope with their symptoms.

Component	Contributions to Root Concept
High-level vision	Patients travel through war-like scenarios using a virtual environment software application monitored by a therapist.
Basic rationale	Virtual environments enable more realistic scenarios. Lifelike graphics and audio enhance immersion. Privacy helps eliminate embarrassment. Constant exposure lessens anxiety levels to stressors. Monitored visits allow therapist to control patient's level of anxiety. Patient response to triggers allow therapist to measure patient's level anxiety.
Stakeholder Groups	
PTSD therapists	More options for treating patients suffering from (PTSD). Increased immersion. Treatment that is easy to commit to. More control over patients anxiety levels. Ability to measure patients' anxiety levels.
Post-war veterans	Require supplemental treatment. Require more realistic graphic and audio. Require less threatening, embarrassing means therapy. Require constant exposure. Require controlled stressors. Require measurable anxiety levels.
Starting Assumptions	Will be built using the services and infrastructure of pre-existing virtual environment gaming software and standard off-the-shelf components.

Table 4: Root concept for virtual environment software application for returning Iraqi veterans with PTSD.

User Analysis

The sample offered here is based on the user profiles of two categories. The first category is that of a post-traumatic stress disorder (PTSD) therapist and the second is that of the patient, a post-war veteran experiencing PTSD symptoms.

User-Profile of PTSD Therapists

PTSD therapists are professional men and woman in the psychotherapy field of healthcare who have traditionally treated post-traumatic stress patients with standard therapy. They include people performing job functions that are an integral part of the healing process. They listen and advise the patient based on their knowledge and experience with PTSD. They will be responsible for the operation of one or more pieces of virtual reality equipment. They will also be responsible for monitoring the patients' anxiety levels based on observation.

User Characteristics

Positive attitude.

Among PTSD therapists, the general attitude towards virtual reality therapy is positive. Technology that can further enhance the therapeutic recovery of patients suffering from PTSD is promising. However, many have not used the technology before.

Education.

The level of education in the field is a graduate degree or above. Most hold a Ph.D. in Clinical Psychology. This high-level of education is a qualifiable requirement for the field. Job experience levels are high in this industry. Many therapists have taught at the university level as well as worked in a variety of clinical settings, both group and private practice (Anderson, 2001).

Usability Requirements

Supplemental therapy.

PTSD therapists require methods of therapy to supplement standard talk therapy. Standard talk therapy is difficult for some patient's, but virtual reality therapy has helped improve patient results when used in conjunction with traditional therapy.

Low learning curve.

They require a low learning curve, due to the inexperience with virtual reality technology products, especially with the aspect that virtual reality is not a requirement in their current job. However, their experience on the job is high and their motivation toward virtual reality technology is also high. This means that the interface should be simple and easy to understand, not complex and difficult to learn.

Text and symbols.

Text and symbols should be relatively large to accommodate for a variety of age groups. This will accommodate both young and old professionals with eyesight restraints (e.g. corrective lenses) (Mahew, 1999).

User Profile of Post-War Veterans

Post-war veterans are returning men and women who served overseas in Iraq experiencing symptoms of PTSD. These patients are looking for ways to return to their civilian lives without difficulty while alleviating the trauma that they experienced during active duty.

User Characteristics

Intrusive thoughts.

Many post-war veterans have intrusive thoughts. They replay one or multiple experiences over and over in their minds. Likely, their subconscious is searching for an alternative to the actual outcome. One that is less disturbing. These thoughts usually entail a military experience. Flashbacks on the other hand are sensory and are triggered by noises, smells, and visual and tactile cues from everyday life (Brossart and O'Dell, 2003).

Isolation.

Returning soldiers may isolate friends and family. This separation is a sign that he/she thinks that no one can understand what has happened to them or are unwilling to listen even if they tried to talk about it. Isolation can be emotional or even geographical. The physicality and/or distance associated with a separate geographical location is a sign of moving away from a problem. Isolation not only affects the veteran but also those closest to them, such as a partner or family members. The person's attitude has changed and they no longer need anyone. They want everyone to leave them alone (Brossart and O'Dell, 2003).

Emotional numbness.

Post-war veterans can be emotional numb, often cold and standoffish. They put up an invisible barrier that helps them to feel in control of their out-of-control emotions (Brossart and O'Dell, 2003).

Depression.

Depression is a common trait among post-war veterans. It stems from insecurities, feelings of helplessness, worthlessness, and sadness. (Brossart and O'Dell, 2003).

Anger.

Severe anger is associated with PTSD. The victim has difficulty recognizing and managing his/her frustrations resulting in unmanageable rage that is frightening to both the veteran and those around them (Brossart and O'Dell, 2003).

Substance abuse.

Misusing nicotine, caffeine, and other drugs to forget painful memories of war is a defense mechanism used by post-war veterans experiencing PTSD (Brossart and O'Dell, 2003).

Guilt/suicidal thoughts and feelings.

Harming oneself in order to feel pain, risking ones own life and other self-destructive behavior can be found in vets with PTSD. They may have guilty feelings over their own survival (Brossart and O'Dell, 2003).

Anxiety or nervousness.

Many soldiers with PTSD are highly conscious of those around them. They do not like people to be too close, it makes them extremely uncomfortable. They are very suspicious of others and have a hard time trusting. They are easy to startle due to the heightened stress of the unknown (Brossart and O'Dell, 2003).

Withdrawn.

Becoming withdrawn and unresponsive is a way for the veteran(s) to separate themselves from people. This distance is intentional and makes it difficult for others to form intimate relationships with them (Brossart and O'Dell, 2003).

Denial.

Last, but certainly not least, is the person's inability to admit or recognize that he/she is experiencing any of the above symptoms and that their exposure to certain activities or events while serving in the military may be a possible cause (Brossart and O'Dell, 2003).

Who Joins the Military and Why?

Eligibility.

There is set of minimum requirements one must meet prior to joining the United States Military. The basic list is short and concise while each branch has an individual interpretation of this list.

The following is a list of the requirements common to all five branches of service; Air Force, Army, National Guard, Coast Guard, Marines and Navy. See Table 5 on the next page for the complete list of qualifications required by each branch.

1. Must be a U.S. citizen or resident alien.
2. Must be at least 17 years old (17-year old applicants require parental consent).
3. Must (with very few exceptions) have a high school diploma.
4. Must pass a physical medical exam.

To join the....	You must:
Air Force	Be between the ages of 17-27.* Have no more than 2 dependants. Pass the Armed Services Vocational Aptitude test (minimum AFQT score: 36).
Army	Be between the ages of 17-42.* Have no more than 2 dependants. Pass the Armed Services Vocational Aptitude test (minimum AFQT score: 31).
National Guard	Be between the ages of 17-42.* Have no more than 2 dependants. Pass the Armed Services Battery Aptitude test (minimum AFQT score: 31).
Coast Guard	Be between the ages of 17-27.* Have no more than 2 dependants. Pass the Armed Services Vocational Aptitude Battery test (minimum AFQT score: 36). Have willingness to serve on or around water.
Marines	Meet exacting physical, mental, and moral standards. Be between the ages of 17-29.* Pass the Armed Services Vocational Aptitude Battery test (minimum AFQT score: 31). Woman are eligible to enlist in all occupations with the exception of combat arms specialties: infantry, tanks and amphibian tractor crew members.
Navy	Be between the ages of 17-34.* Pass the Armed Services Vocational Aptitude Battery test (minimum AFQT score: 35). Woman are eligible to enlist in all occupational fields with the exception of serving the Navy SEALs or on submarines.

Table 5: Complete list of requirements for each branch of service (http://www.military.com/Recruiting/Content/0,13898,rec_step02_reasons,,00.htmlx).

Motivation for Joining the Military

Each person's motivation for joining the military is personal. Some common reasons for joining the present day military are:

1. Answering the call to serve one's country
2. Taking a stand against terrorism
3. Educational and monetary benefits that can last a lifetime
4. Personal satisfaction and pride
5. Family tradition
6. Honor
7. Devotion to duty
8. Learning useful new skills
9. Full-time employment
10. Job Security
11. Personal improvement

Once again, these are just a few, there are thousands, and all are different and personal. (http://www.military.com/Recruiting/Content/0,13898,rec_step02_reasons,,00.htmlx)

Usability Requirements

Privacy.

Post-war veterans require private one-on-one treatments with a PTSD therapist. This decreases their level of embarrassment or shame felt about having the disorder.

Ease of use.

They also require low learning curves, due to inexperience with virtual reality technology products.

Computer knowledge.

Veterans require a system where basic computer knowledge is acceptable. Experience using a keyboard and /or video game control is not required but beneficial.

Aesthetics and audio.

They require lifelike graphics and audio for increased realism. This will enhance patient immersion and increase the speed of the healing process.

Language.

Veterans require low level reading standards comparable to that of a 6th grader. Therefore the language and naming conventions chosen for written components of the software must be basic and simple, not complex or hard to understand.

Terminology.

Veterans must be familiar with the names of specific military weaponry and understand standard military lingo. Specific orders regarding mission completion will be mimicked in the audio and captions of this product. Therefore, the vocabulary used in the instructions must be reminiscent of a specific branch of military jargon.

Support multiple learning styles.

This software application must support a variety of learning styles by providing information in multiple ways. Information will be given both textually and visually. Buttons will be available to enter and cancel inputs, as well as continue to next screen or move back to previous screen. These buttons will appear at the bottom of the screen in every instance. They are available to provide consistency and easy location. They will be large and contrast with the background of the software for easy recognition. The system will also incorporate audio as another option for getting information as well as closed caption.

Motivations for Using Virtual Environment Software

Internal motivations.

Veterans' internal motivations are successful mission completion. Also the ability to use the software in private is an internal motivator.

External motivations.

Veterans' external motivations are overcoming depression and anxiety. The return to "normal" is the relative goal. Each person being treated with this software is trying to get back to a place where they felt "good" before being in a war.

Product Appeal

Accommodating user likes and dislikes is extremely important when designing a product for ultimate usability. The following paragraphs expand on a compilation of elements that are appealing to large groups of users and will aid in the overall product usability if incorporated into the system design.

Appealing to Group

Flexible technology.

Cross-platform flexibility is very important to functionality in today's software design. Not everyone is using the same technology and products that have the ability to be used on multiple platforms reach larger groups of people because they are not required to buy new equipment to use your product.

Ease of use.

The system navigation must be intuitive for increased ease of use. If a user has difficulty finding where they are or where they want to go within a system frustrations are sparked and users will avoid the system. Why would you want to use a product that is difficult to find your way around?

Immersion.

Immersion is the key to success when treating patients with PTSD. The elements that follow can provide for the difference between patient immersion and difficulty with patient immersion.

Aesthetics.

Realistic graphic representations are used to enhance patient immersion. By reproducing the ambiance of real life situations patients allow themselves to be transported to a specific time and place. Realistic aesthetics make it easier for patients to immerse in the atmosphere being recreated for them. For example, scenes that use similar colors and architecture of the place you are trying to recreate enhance immersion capabilities. The men and women who will be treated with the virtual environment being recreated here should expect a desert color scheme that will emulate the sandy ground and building colors that one would expect to see in Iraq. Also the types of homes and buildings should be in the correct architectural style and materials. You wouldn't see skyscrapers in Iraq but you would in New York City.

Real-time response.

Along with lifelike graphic imagery, real-time responses are also beneficial to recreating an environment that feels natural. The more natural the mood, the more realistic it seems, which makes it easier for users to forget what is going on around them when they are playing the game. Their attention is focused on the setting in front of them, not the dog barking in the background.

Functionality.

Functionality is also extremely important to a user's ability to immerse. Interface buttons and input boxes must be clearly labeled and easy to locate so that users will not be distracted from the main purpose of their mission. Unclear instructions can also distract users. When forced to think about what something means users temporarily remove themselves from the environment and are no longer fully immersed in the mission.

Confidence.

The ability to move at ones own pace through treatment is appealing because it allows users to gain confidence with each session. They are not forced to encounter difficult situations they may or may not be ready for at a particular stage in their therapy. The constant exposure to the feared stimuli is what gives users the confidence to deal with their anxieties. Some patients gain this confidence faster than others. Every user is able to move at their own speed, creating a personalized recovery time.

Unappealing to Group

Complexity.

Complex directions and labels, small, hard to read fonts, hidden options and controls that are hard to maneuver all impact the learning curve in a negative way. Large learning curves are unappealing and all the elements that contribute to an increased learning curve are viewed negatively.

Poor aesthetics.

Unrealistic graphics, including architecture that is out of context and an incorrect color scheme, such as forest vs. desert, alter the environments realism. These visual elements affect the level of immersion possible in the system. If the characteristics of the environment that is being recreated are inaccurate the system loses its appeal and ability to take the user back to a specific time and place.

Colors also elicit different emotions and feelings. If there is a lack of color in an environment or limited color options the user is not able to customize the environment to benefit his/her experience. If there is only one color option, the change in feelings between different environments is limited and does not accurately evoke the time and place that is being recreated. For example, in a desert themed environment the mass of sand and heat are expressed through warm colors like browns and tans. When the user switches to an urban environment the color tones change from tans to grays and are reminiscent of cement buildings. The lack of a theme for each environment also stifles the users' ability to fully immerse. The recreation of the battlefield must incorporate a variety of thematic options such as, desert scenes, urban scenes, infirmary posts, military housing scenes, enemies and civilians. These visual aids trigger emotions that the user felt when he/she was actually there.

Lack of sound.

Sound effects, music and overall theme add to the realism of an environment as well. If there is no sound it becomes hard for the user to imagine what sound a gun being fired makes, how a bomb going off sounds, or what people screaming sound like. Without the noise, these sounds are left to the users' imagination and make it more difficult for them to become immersed in the game because they have to think about these things rather than them being seamlessly incorporated into the overall experience.

Implications of Design

The following implications of design are based on information in the literature review. Each has an important role in the virtual environment software application and is measurable in order to determine how useful it is.

Privacy.

Whether or not a patient seeks treatment or returns to treatment is largely based on their comfort level. If a patient is uncomfortable or embarrassed by his/her disorder they are unlikely to seek treatment, therefore it is a very important component of this system design. Privacy in treatment protects patients from onlookers and alleviates feelings of embarrassment, which can be a mental barrier for patients. The design of a virtual environment in conjunction with one-on-one therapy is much more private than a group therapy session. Privacy is measured by how comfortable the patient is with the system by their willingness to return to treatment.

Ease of first-time use.

The ease of first time use in this scenario is extremely important. It will help the user gain confidence. If the user's first impression of the system is awkward and complex there is the chance that they will be turned off to treatment all together. It is crucial that these users do not discontinue their treatment. Already many people with PTSD do not seek treatment because of a lack of knowledge of what is available to them, or embarrassment and shyness can also be blamed. Engaging in treatment can help improve their lives. Without it, suffering can be life-long. The ease-of-use of the system is measured in terms of how easily the user can learn the software with or without training.

Expert level use.

The PTSD therapists will be using the software on a different level than the patients. They play the role of the observer and require a higher level of expertise because they monitor the patient's progress and determine the pace that the patient should move forward through the environments. This is measured by the patient's confidence level with each new stimulus. The more they are exposed to a stimulus the more confident they become with it. Once their confidence has increased the progression to the next environment can begin.

Efficiency.

The system needs to be efficient in order to smoothly move the user through the various scenarios at a speed that is comparable to a real life event. This system needs to mimic real life in every aspect possible and the speed of mission completion is no exception. If a person is shooting at the enemy, the effect of that shot needs to appear in real-time. The faster the user is able to see the result of their actions, the more confident they will be as they progress to higher-stress scenarios. The efficiency of the system is measured by how quickly something happens on screen and when it reaches the patient. If there are gaps in the experience the system is not working as hard for the patient than if the action and feedback are simultaneous.

Aesthetics.

The aesthetics of the system are one of the main components that will or will not transport patients back to Iraq. Therefore the look and feel of the system is extremely important to the successful treatment of the patients since it is supposed to resemble another time and place. The more immersed the users can become, the easier it will be for them to believe that they are actually back in Iraq. Moreover, descriptive information needs to be clear and easy to access without interrupting the overall ambiance of the mission. Color choices and fonts should be consistent throughout. Repetition will provide predictability and make users feel more comfortable with the system as well as make it easier and faster for them to learn it. This consistent look and feel from one mission to another will create a smooth transition of information for the user. The measurement of aesthetics can be subjective and may vary between the different individual learning styles. In this case, the aesthetics will be measured by the level of immersion patients' experience. The use of realistic graphics makes the environments more reminiscent of real life experiences, in turn producing higher levels of immersion. Gestalt principles of placement also enhance the experience. The effectiveness of these principles can be measured by how little they interfere with the actual scenarios. Interactive objects are placed on a screen where they are easy to recognize and locate yet remain unobtrusive, almost ubiquitous.

Target Audience

PTSD therapists in the psychotherapy field and returning Iraqi veterans, between the ages of 17 and 62 make up the target audience for this system. Findings in the literature review are the foundation for this assertion.

User Persona

The user persona helps the development team understand users' current practices, before the new technology. It is an easy way to recognize the pros and cons of past activities and determine what is working and what is not, and then figure out how to incorporate or improve them in the new system. The descriptions below are hypothetical scenarios of two patients and their therapy experiences prior to virtual environment software applications.

1.) Nineteen-year-old Rob is a soldier recently home from a one-year term in Iraq. Unable to find civilian work due to severe depression, a result of the war, he is undergoing treatment for PTSD with standard talk therapy. Rob participates in group therapy sessions made up of seven other men and women with similar military backgrounds and experiences. Rob is having a hard time with these sessions because he is uncomfortable. He has trouble talking in front of others. Because Rob's group therapy lacks privacy he is not as open with his issues and concerns as he would be in private, somewhere he felt more confident. This is detrimental to the success of his therapy. This current form of therapy is a struggle for Rob and he is not experiencing any great benefit from it. In hindsight he is more stressed out and anxious. He is thinking about discontinuing his therapy by not returning to group sessions.

2.) Kristy is a veteran of the "war on terror." While overseas she was a nurse who treated injured soldiers but she did not fight on the battlefield. She is severely disturbed by her experience overseas and continues to have very graphic nightmares more than a year later. Kristy is being treated for depression and anxiety. She is able to talk about her early experiences in Iraq quite easily but once the conversation changes from peaceful to chaotic and injuries are brought up that she witnessed in the nursing quarters she becomes disturbed. These disturbing memories increase her anxiety. Her therapist does not always pick up on the effect that this topic has on her and will often times probe her to move forward and talk about more difficult subject matter. When her therapist does recognize Kristy's discomfort with a subject they slow down and spend more time on the topic before moving forward. This is ideal for Kristy because she is then able to deal with each anxiety individually, overcoming one before moving on to another. She has been in therapy for two months and is making progress. Her stress level, when blood stained soldiers are brought up, measures her progress but if she does not show any external or physical signs of stress her therapist is unaware of the anxiety. Unfortunately, like many others, Kristy tends to internalize her emotions with regards to her time in Iraq making it difficult, if not impossible, for her therapist to pin point the triggers that are causing her stress. She is slowly becoming more comfortable with certain memories that are continuously revisited in her therapy sessions but she is not fully healed. She is frustrated with the slow progress standard talk therapy offers and is tired of taking daily anxiety medications prescribed by her psychologist. She is thinking about discontinuing her therapy.

Problem Scenario 1

It has been two months since Rob returned home from the war. He has difficulty dealing with the change and feelings of guilt he has brought home with him. He has been actively involved in a support group for returning veterans for about a month but has not been able to alleviate any of his PTSD symptoms through communication therapy alone. Talking with others of a similar background should be comforting but Rob is a private person. Rob is able to talk in the meetings about his experiences but is not comfortable doing so. Rather than improving Rob's psyche, the meetings seem to be making him more anxious. Rob is glad to know that he is not alone but wishes there was a way that he could express himself without the internal embarrassment he feels.

Problem Scenario 2

Since returning from Iraq, Rob has been overcome with anxiety and nervousness. He can't even go out with friends anymore without feeling overwhelmed. Large crowds and startling noises put him on edge. His friends don't understand what has changed and why he doesn't come around as often as he did before going to war. He has withdrawn from those he is closest too. He has heard about PTSD but is not sure if he fits the stigma. He feels ashamed that he is experiencing these symptoms. He decides to attend standard one-on-one therapy to talk through his issues. The idea of therapy is promising at first but eventually Rob feels that his progress is static. He feels that something is missing. Without audio and visual stimuli he is unable to recreate the scenes that trigger his discomfort. Since his anxiety stems from common everyday noises, sound is an integral part in the healing process.

Claims Analysis for Problem Scenarios

Situation Features	Pros(+) and Cons(-)
Current support group	+ Robust way of expressing ones self with others with similar backgrounds + Easy to become a member -No leader with certification or medical degree present No privacy No visual stimuli No way to measure progress Feelings of embarrassment
Current one-on-one therapy	+Safe environment to talk in. +Led by a medical professional. +Private. -No visual stimuli. -No audio stimuli. -Difficult to measure progress. -Slow progress. -No exposure. -Little or no immersion.

Table 6: Claims Analysis for scenarios.

Usability Requirements Summary

The following table is a summary of the most important usability requirements according to each user category.

Key: blank=not important, x=important, xx=very important

	Low learning curve	Privacy	Simplicity	Realism	Language	Physical impairments	Vision restraints
PTSD therapist	x	xx	xx	xx	x		xx
Post-war veterans	x	xx	xx	xx	xx		x

Table 7: Summary of the important usability requirements.

Activity Scenarios

Scenario 1.

Rob has been participating in a support group for over a month. It is good to know he is not alone but he is embarrassed to express his feelings within a group of people. He would feel more comfortable working one-on-one. Rob begins to see a therapist one-on-one and does not return to the group. The therapist introduces him to a virtual environment made specifically for returning veterans with PTSD. This alleviates Rob's feelings of discomfort within a group and allows him visual stimulation that can bring him back to his time in Iraq at a pace he is comfortable with. His progression is measured by the completion of tasks and the therapist guides the speed in which he completes each task based on the stress levels he exerts throughout each session. Rob is happy with this new treatment and has begun to feel some improvement in both his mood and anxiety levels.

Scenario 2.

Rob is a soldier who has recently returned home from Iraq who has previously sought treatment for PTSD. He is curious about therapy that utilizes VE to treat patients with PTSD and wonders how it will differ from his past experience with therapy. He hopes that his symptoms will improve more rapidly than with talk therapy alone. He also hopes that there will be visual and audio stimulation to help recreate an actual physical time and place. When Rob decides to move forward with virtual environment therapy he is afraid it will be difficult to use and that visuals may be unrealistic and outdated.

When Rob arrives for his first VE therapy session he sees a user interface much like the one on his computer at home. Initially this is comforting but then he worries that the environment may not be reminiscent of Iraq. On closer look, he sees that there are different environments to choose from. He has the flexibility to choose a desert scene as well as enter his personal profile into the system. For example, he can choose a soldier with the same hair color, eye color, skin color, sex, height and build as his real life counterpart. Rob realizes that the closer he and his character look alike, the easier it will be to imagine he is back in Iraq. All this is very exciting but he still needs a way to hear sounds that trigger his anxiety's to overcome his fears.

Information Design

Scenario 1.

When Rob arrives at his appointment with the therapist he begins each session with a conversation in a comfortable, family room type setting, one-on-one with the therapist to express how things have been going for him. This relaxes him and lets the therapist decide at what pace they should continue. It also allows the therapist to respond to what Rob has said. This response may help him deal with issues better in the upcoming week.

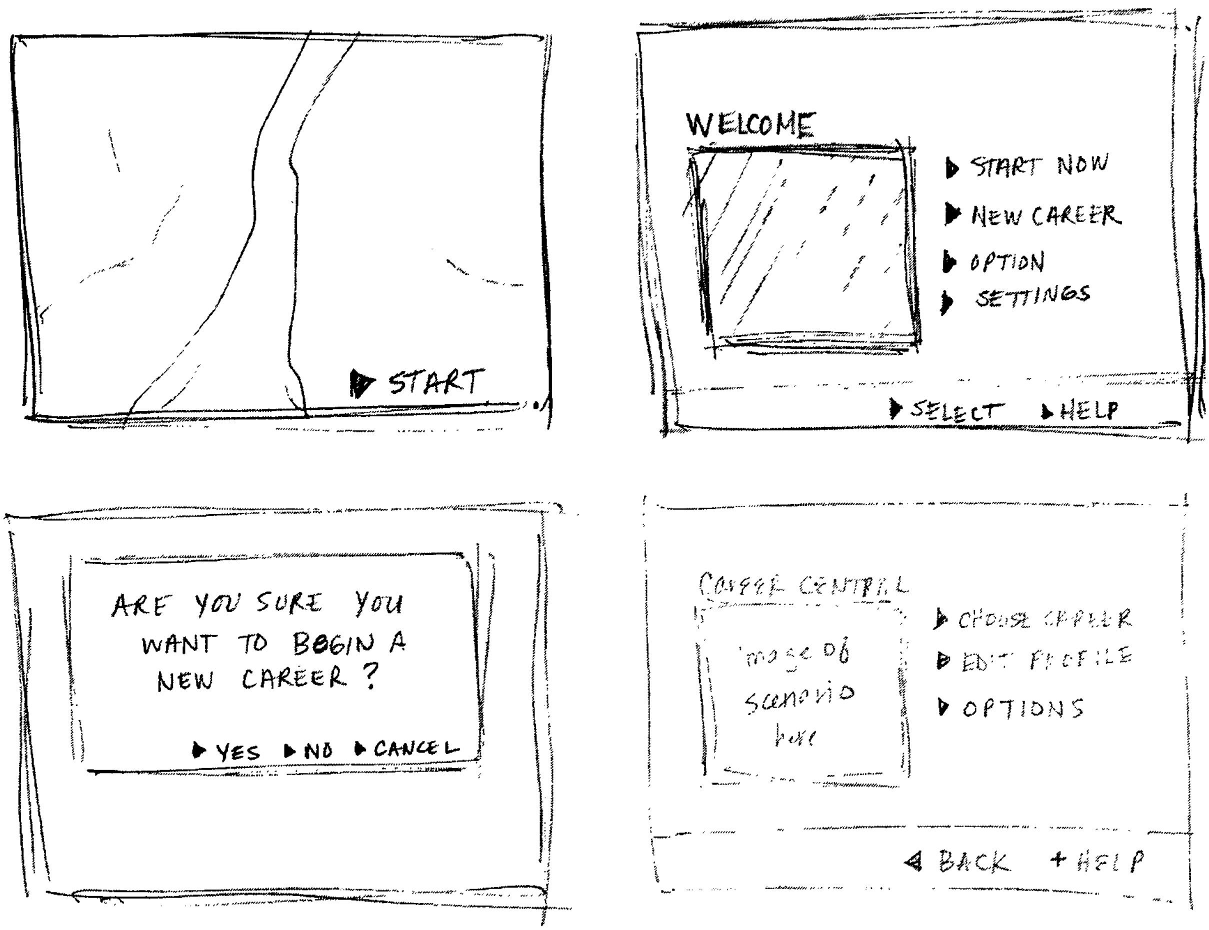
They begin the virtual session by logging onto the system that is set-up in the laboratory. Rob inputs his name and chooses his options as prompted by the system. Once all of the information is input, he can go to the system map that is a visual depiction of the route in which each patient takes through his/her journey through Iraq. Rob chooses the icon on the map that is highlighted, which indicates his starting point. A new screen appears and welcomes Rob. He is now prompted to select his options which include career choice, environment, transportation, soldier style, and audio. In doing so he chooses to save these options, which will shorten his log-in time in the future. Once his character is developed he saves his profile and begins his journey. An introduction paragraph appears to explain his mission. Each screen has both text and a narrator's version of the text to guide the soldier through each mission. The soldier can choose to turn one or both off during the setting of preferences. It is usually beneficial for beginners to have this aid turned on as it serves as a virtual guide or as a virtual team member. When Rob makes his way through each mission the stimuli increase until he has reached a climax where the triggers are affecting his anxiety levels and the therapist decides it is a good time to stop. Rob chooses to quit the program, but before doing so the application prompts him to save his progress. He clicks the accept button. Then the program asks if he is sure he wants to quit. He also clicks accept button and the session is saved and the program exited.

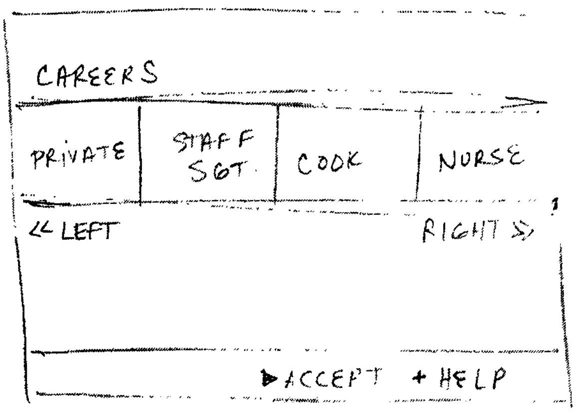
Scenario 2.

As Rob continues his VE therapy he is pleasantly surprised with the systems ease of use. The map navigation concept used by the system is similar to the actual maps he used throughout his tour in Iraq to navigate the land. Rob sees a tan dot on the map and realizes that this indicates his placement on the map. Now he can determine where he is within the VE and where he can go. The map contains visuals that depict different missions. Rob clicks through a few different mission blocks then decides to go back to choose an urban scene. He accepts this change via a pop-up window that prompts him to accept the change or cancel. At the beginning of each new mission an introduction screen appears and a story is told via audio (if sound is on) and/or text. This story sets the stage for the upcoming mission and helps create a virtual Iraq. The storyline, along with the visuals and sound effects improve a patient's immersion because of the realistic premise each is based on. As Rob continues through his mission the map is still on the screen but its size has been reduced and its placement is not intrusive to the overall imagery. It appears in the lower left hand corner of the screen. The map icon is a visual aid of Rob's placement throughout the mission as well as the enemies. The more enemies Rob encounters the more stressed he becomes. The therapist recognizes Rob's symptoms of anxiety and decides it is a good place to end. Rob completes the mission and saves his mission. He is then asked if he is sure he'd like to quit and he replies by clicking accept/yes. His other option would be to cancel the request and continue his mission.

Storyboard.

The following sketches make up the storyboard created for this software product. Each depicts an initial rough sketch of a screen that users see. Interface layout, menus, and patient options are realized here. These beginning ideas can be quickly revised to incorporate new ideas and are not final at this stage.

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STAFF SGT.
COOK
NURSE
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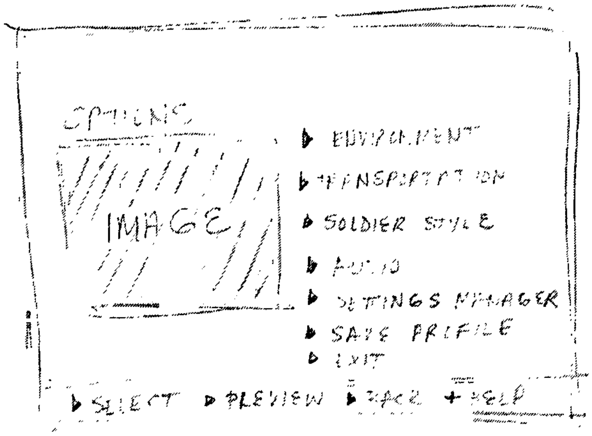
+ HELP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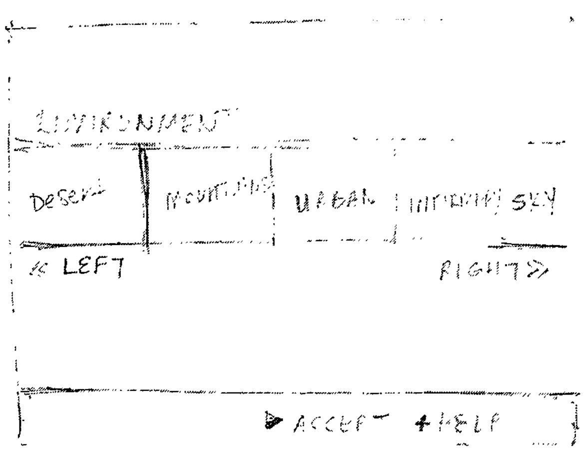
SETTINGS MANAGER
SAVE PROFILE
SELECT
PREVIEW
+ HELP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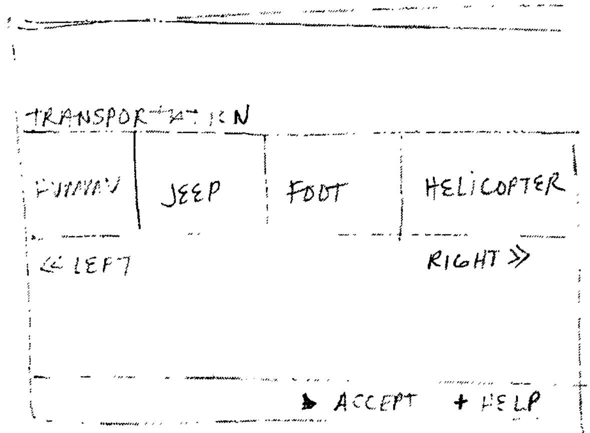
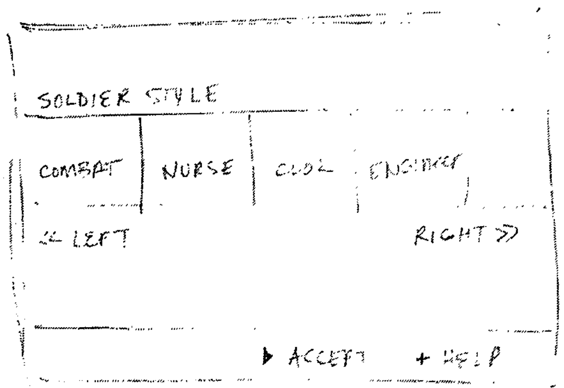
ACCEPT
+ HELP


TRANSPORTATION
JEEP
FOOT
HELICOPTER
<< LEFT
RIGHT >>
ACCEPT
+ HELP


SOLDIER STYLE
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NURSE
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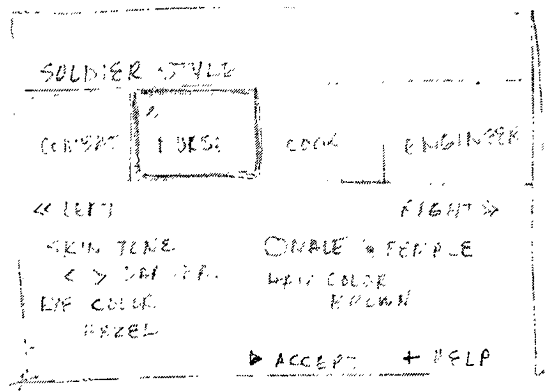
SOLDIER STYLE
COMBAT
ENGINEER
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SKIN TONE
EYE COLOR
HAZEL
MALE
FEMALE
ACCEPT
+ HELP

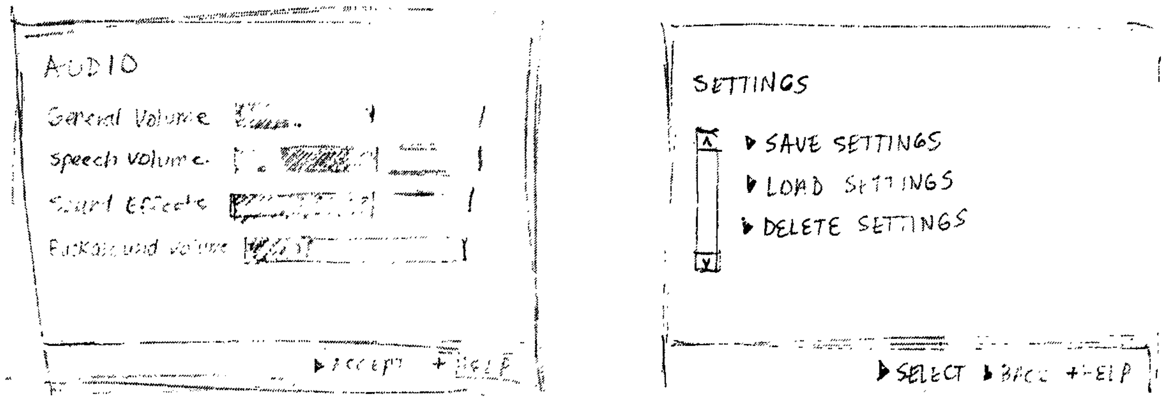


Figure 11: Sample storyboard sketches.

Interaction Design

Input devices.

Device	Input characteristics	Sample applications
Button	Simple isolated input. Discrete.	Accept or cancel entry.
Keyboard	Small finger movements. Enter text. Accommodates combination key entries. Discrete.	Enter information in input boxes. Keyboard shortcuts.
Mouse	Move with one hand. One or more buttons. Left and right click. Large arm movement. Analog.	Point and select in 2D space.

Table 8: Sample input devices and their attributes.

System metaphors.

Virtual Iraq interaction	Real-world metaphor	Ideas about virtual Iraq interaction design
Viewing VE is like…	Video game	Use menus and icons to make selections and decisions. Click objects to learn more. Use mouse to make characters to things.
Visiting VE is like…	Returning to Iraq	Rotation for full views.

	Interactive map	View entire VE or magnify details by zooming. Choose area of interest. Click to move to new location.
Navigating VE is like…	Viewing a map	Interactive map icon to navigate VE and place users. Find places of interest. Choose area of interest. Click to move to new location.
Setting up user profiles is like…	Shopping, add items to cart.	Select options from menus and add to user profile. Save user profile by clicking.

Table 9: Metaphors for virtual Iraq, with emphasis on interaction design.

Scenario 1.

Rob begins his VE therapy session by logging into the system via a login screen. When prompted for his username and password he types each into the separate input boxes provided using a standard computer keyboard and enters the information by mouse clicking the accept button. By creating a user name and password Rob is able to retrieve prior user profiles and mission status allowing him to begin therapy where he left off. The system has stored his user profile from the initial preferences he set up. When he enters the VE he recognizes the environment, an urban street scene, a map in the lower left hand corner and blinking tan dot indicating his position, and various icons placed on the VE. Rob references the map icon to see where he has been, where he is currently, and where he can go next. He chooses the flashing tan dot on the map that is symbolic of the VE soldier he created. His name appears on the screen as indicated in his user profiles along side the tan dot in the upper portion of the screen. This lets other users know who is in the VE. These others users can be logged in from home or other laboratory settings. This allows Rob to be anonymous. It also allows the therapist to see who is in the VE. Rob chooses his next mission on the map and accepts his choice. He enters the VE and can move through the scene using the mouse. As he passes areas that contain enemies or other users each is identified by a flashing dot. Enemies are red flashing dots, a system standard, and users are custom color dots, other than red, created by editing their own user profiles. Each user chose their own personal color to indicate their soldier, like a game piece is chosen at the beginning of a board game.

As Rob moves through the VE, in a custom military vehicle of his choice that was created during his user profile set up, sounds of explosions and foreign screams can be heard. Various imagery and icons are clickable throughout the VE. When clicked, a separate pop-up window appears with a brief description to let Rob know what he can do with the item. For example, a black bag with a red cross on it is abandoned on the side of the road. Rob clicks the image with his mouse, in a separate window the text instructs Rob that this is a health icon and will improve his health by repairing injuries that he may have incurred along the way. Another example is that of a door of a building. He clicks the door and the pop-up explains that by pushing the door Rob will be allowed to enter the building. It also describes the scene inside the building and instructs Rob to rescue hurt soldiers and get them to the infirmary.

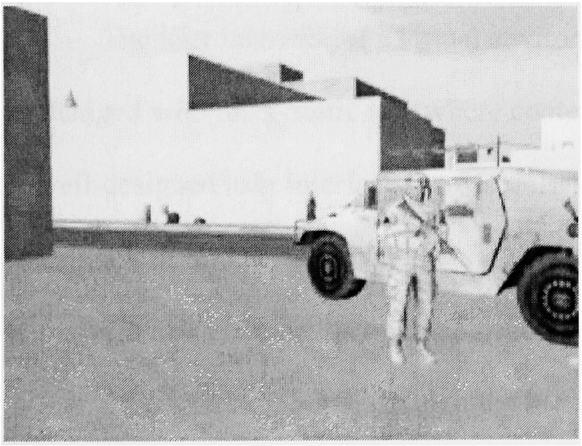
Scenario 2.

The systems flexibility allows Rob to choose a companion for his mission. He chooses from a menu of generic characters provided by the system. The companion is similar to Rob traveling with another member of his squadron in real life. The companion is another object that will be in the mission but is controlled by the computer not by the user. As Rob and the soldier travel through the urban street scene shots are heard and the companion is hit. Rob is able to remove his character from the vehicle they are traveling in and open the door where the injured soldier is sitting and carry the soldier to the infirmary, all with the use of the mouse and its various buttons. As Rob picks the soldier up, he continues through the mission on foot. He references the map icon and it shows his colored dot icon moving simultaneously. The map is Rob's navigation tool and he follows the paths to the infirmary icon shown on the map.

Prototyping

Scenario machine.

The screen shots depicted below illustrate a sample sequence of events that could be viewed by users when using a virtual reality software application for their PTSD treatment. The scenario is that of a pair of soldiers traveling down a violent urban street in wartime Iraq.



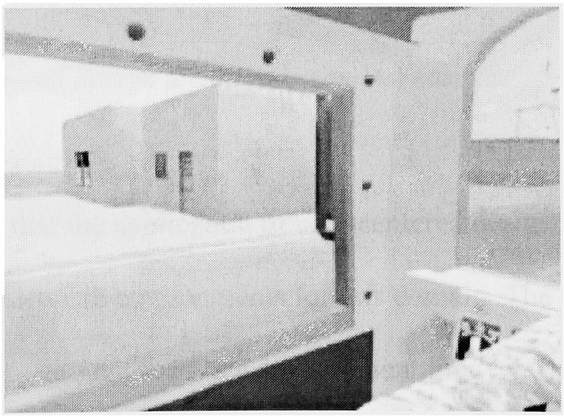


Figure 12: Sample scenario using the scenario machine prototype approach (Braiker, 2007).

DISCUSSION AND CONCLUSION

The user interface of a virtual environment is the window through which information is exchanged with the system. It is where content and relevant information is retrieved by the user. A well-designed user interface increases user performance by allowing for simple and natural transitions from one task to another. However, an interface that is designed poorly requires users to perform tasks that are difficult and complex (Preece, 1995).

This study supports, through the literature review and development of a case study, three hypotheses.

Hypothesis 1: *The application of user-centered design techniques can increase the usability of current virtual environment therapy software.*

This study begins to support the argument that the application of user-centered design techniques is valuable in the development of VE software environments for this domain. The application of user-centered design techniques throughout a software development lifecycle can increase product usability by involving the user throughout the development process. Strong findings throughout the literature review point to the belief that keeping the user experience and their requirements at the forefront of a design project will produce a more usable product. These findings could have been strengthened had there been access to actual participants but due to privacy issues involved with patient confidentiality the strategy of interviews and observation was not employed. All findings rely heavily on past research and current affairs.

Hypothesis 2: *Current technology is good enough to help people overcome anxieties related to certain mental health disorders.*

One area of exploration in VR technology is the treatment of mental health disorders. Some studies have recorded results that look promising (Schuemie, 2002). A variety of studies were researched and found to have produced improved patient results by introducing virtual reality therapy in conjunction with standard talk therapy. The studies described in the literature review detail the improvements that therapists' experienced with their patients. Each patient-therapist relationship is unique but findings remained consistent that with the addition of VR therapy patients were able to immerse more easily and lessen their individual anxieties associated with specific fears. Nonetheless, communication with actual therapists and post-war veterans was unavailable; this question still cannot be answered with full resolve.

Hypothesis 3: *Human factors can improve current virtual reality technology.*

Based on the literature review, human factors can improve VR technology by keeping users needs in mind throughout the entire development process. When developers work with users to improve technology, a better, more user friendly product is usually the outcome. Simplified system navigation and an enhanced user experience can be achieved through the application of user-centered design tools and techniques. As software designers it is imperative to create products that neither confuse nor frustrate the end user. Successful product interface design presents information in an organized way that is easy for users to interpret. Therefore, one of the main jobs of a software designer is to clearly communicate information and concepts to the end user (Turner, 1998). This study concentrated on the design of the user interface, apart from evaluation, the typical process of testing prior to implementation in interface design. By using scenario-based design methodologies, developers learn who their audience is and what is required to make the end product usable, while satisfying the needs of all involved. Without this perspective of the end user, designers would be forced to guess user requirements and how different users will interact with the system. By having open communication with users, design problems can be solved long before implementation. Knowing your audience and their work habits is an important factor in the scenario-based design process (Turner, 1998).

In conclusion, although the evaluation process has been an integral part of improving product design for decades, this case promoted enhanced product design by generating useful information through an extensive literature review, which aided in the completion of a case study. The case study illustrates how to lead a software design team through the development of a VE application for the treatment of a mental health disorder. Applying scenario-based tools and techniques throughout the process allowed for increased product usability through continuous user involvement. Designers will continue to improve the development process by constantly acknowledging the needs and practices of the users, by including them throughout the entire development process and better understanding these needs and how good design supports communication and decision making when using a product (Turner, 1998).

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